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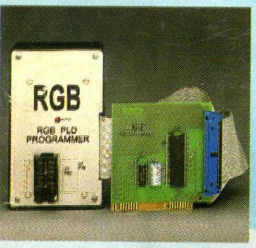

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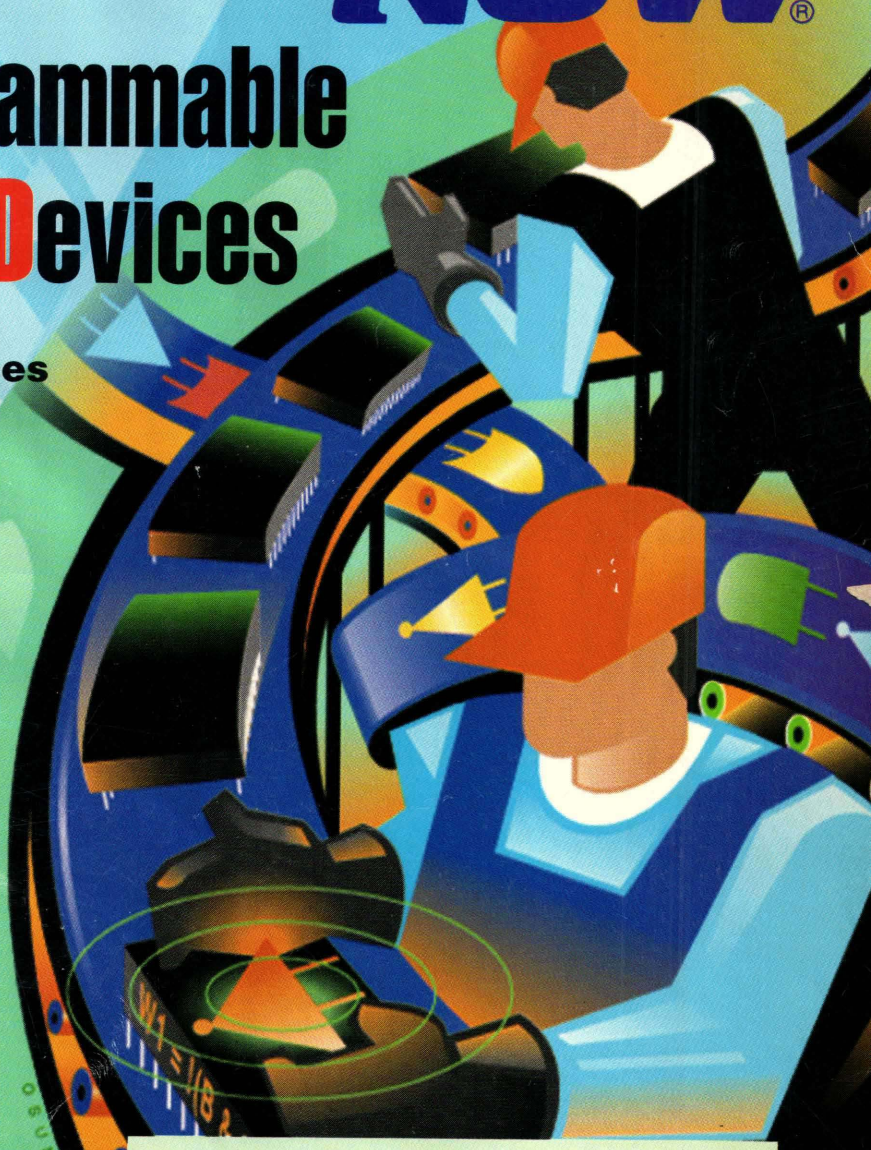

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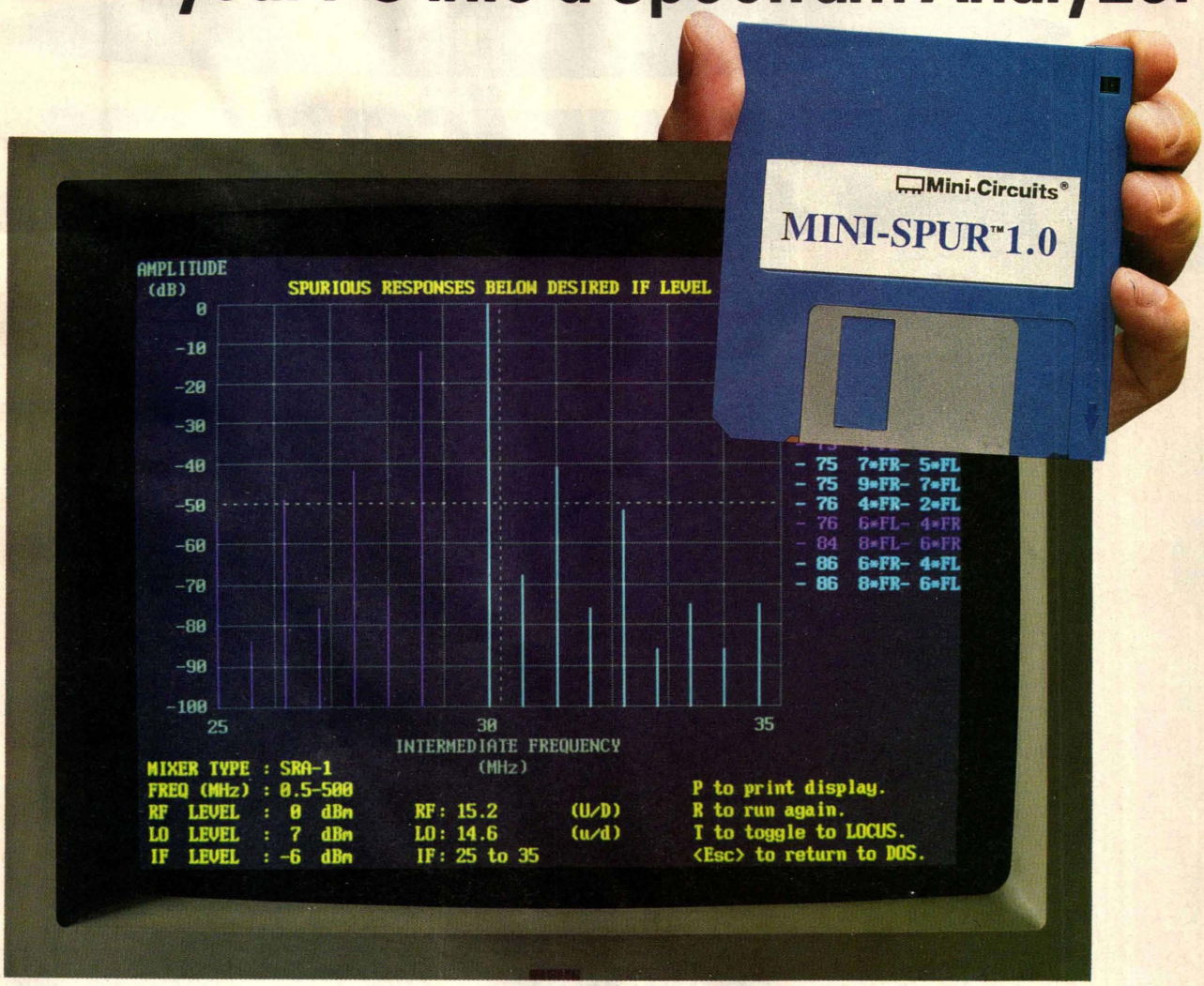

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Robert G. Brown

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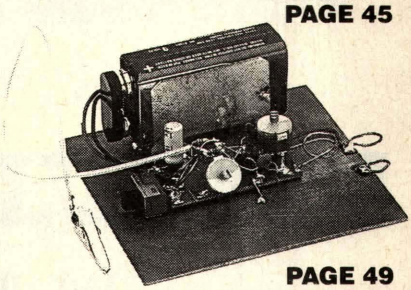

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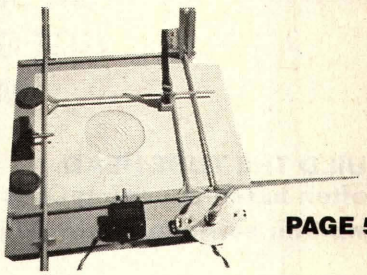

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ON THE COVER

Every engineer and technician should be familiar with programmable logic devices, or PLD's. After reading our cover stories, even those who aren't doing component-level logic design on a daily basis will be able to experiment with programmable devices and see for themselves how PLD's can save PC-board space, reduce cost, and add design flexibility when compared to standard TTL. Turn to page 31 to get started with "Designing with Programmable Logic," a PLD refresher course complete with a look at how PLD's can simplify logic designs. Keep reading! On page 39 we show you how to build a very affordable PLD programmer.

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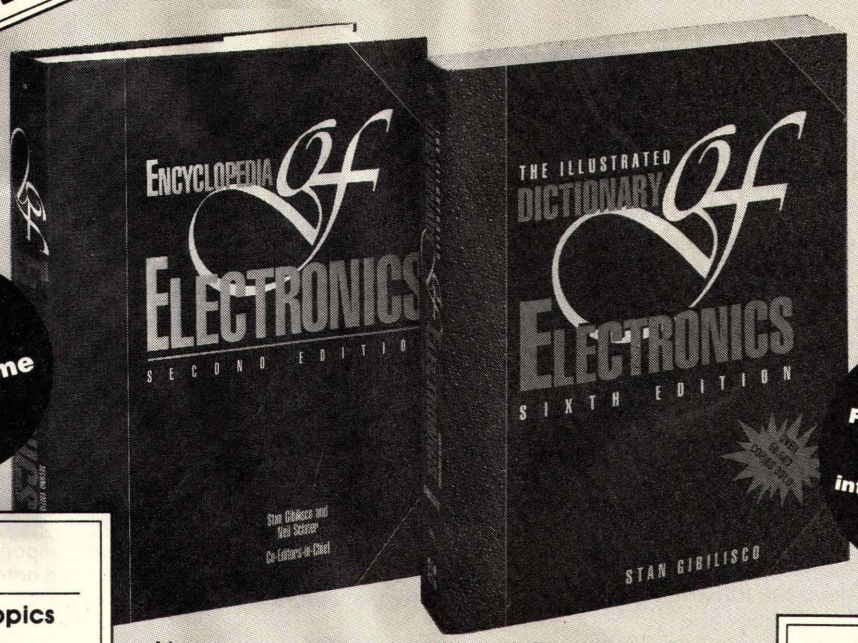

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WHAT'S NEWS

A review of the latest happenings in electronics.

Digital micromirror device improved

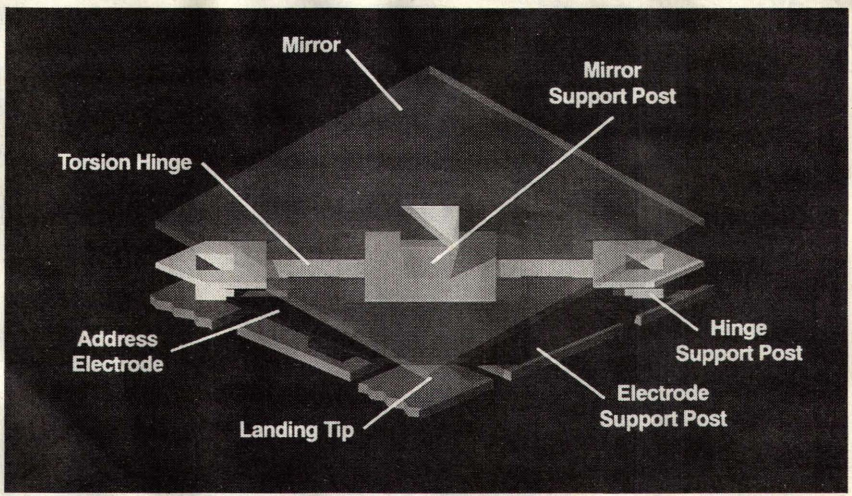
Texas Instruments has improved its previously announced digital micromirror device (DMD) that is intended to replace cathode ray tube (CRT) and liquid crystal light valve (LCLV) projectors in large-screen projection television receivers. The latest modification has increased the effective mirror area on each device.

The DMD, which measures less than 5/8 inch on each side, consists of an array of more than 400,000 movable microminiature mirrors formed on top of a driver device. Essentially a CMOS static read-only memory (SRAM), the driver contains the logic, memory and control circuitry.

Digital signals from a computer cause the mirrors to flip-flop back and forth between two contacts under the control of the substrate chip. The DMD reflects light directed on it, and the positions of the mirrors at any given time determine the image that can be projected. The DMD, like the LCLV, is classed as a spatial light modulator or SLM because its operation depends on its ability to reflect light from an external source.

The DMD is made by fabricating the base driver chip by standard CMOS fabrication techniques. Then layers of reflective aluminum alloy are deposited on that substrate and etched away to form the array of 17-micron square micromirrors supported by structures that permit all of them to move through ± 10° angles.

Each mirror is attached at two diagonally opposite corners to support pillars by flexible torsion bars. (see Fig. 1) The support pillars suspend each mirror about 2 microns above the surface of the driver, which provides the electrical signals and electrostatic forces that cause the mirrors to "see-saw" from one contact to another.



DIGITAL MICROMIRROR DEVICE from Texas Instruments responds to digital signals from a computer to form colored images that can be reflected onto a large screen. The supporting structures for the mirrors are hidden in this modification.

The micromirrors are arranged in an X-Y array and the driver device contains row drivers, column drivers, and timing circuitry. The addressing circuitry under each mirror pixel is a memory cell that drives two electrodes under the mirror with complementary voltages.

The electrodes are arrayed on opposite sides of the rotational axis that runs through the torsion bar attachments. The mirror is held at ground potential by an electrical connection from the support pillars and torsion bar.

When the electrode on one side of the rotational axis is driven to a logic high, the electrostatic attraction on that side of the axis rotates the mirror around the axis until the unattached mirror corner on that side contacts a metal pad on the chip.

TI has improved its original DMD by fabricating the pillars that support the mirrors so they are hidden under the mirrors. This has permitted an increase in the number of mirrors that can be formed atop the chip by making better use of the space formerly occupied by the support structures.

A working projection system consists of an arc lamp that directs white light through a lens and motor-driven color wheel containing red, green and blue filters onto the mirrors of the DMD. Input signals from a computer control the positions of the mirrors so they reflect light to create the desired image. Zoom lenses project that image onto a 60-inch screen about 12 feet away.

Each DMD measures 0.594 × 0.501 inch and is packaged in a 96-pin ceramic package with a window treated to minimize reflections. The 442,368 mirrors permit the device to support both the 768 × 576 pixel PAL and 640 × 480 pixel NTSC formats. The images stored in the memory cell beneath the mirror can be printed and displayed as well as projected.

U.S. regains patent lead

The International Business Machines Corporation has lost market share in mainframe computers, let go 60,000 employees in downsizing, and recently changed its top management. Nevertheless, it remains a premier source of patentable ideas. IBM received 1099 U.S.

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VIDEO NEWS

What's new in the fast-changing video industry.

DAVID LACHENBRUCH

• Nintendo versus Sega. Momentum has shifted in the video-game wars, with Sonic sharply gaining on Mario as both prepare for further competition in on-line game systems. For home-console systems, Sega plans to capitalize on its current advantage with its Saturn 32-bit system, which essentially will bring graphics workstation technology into a consumer game product. Parallel processing by nine microprocessors, including three graphics coprocessors and two 32-bit RISC chips, will permit the system to achieve a speed equivalent to a single chip at 800 MIPS. It has 36 megabits of RAM, including a RAM devoted exclusively to sound processing. The double-speed CD-ROM drive will allow faster access, a must for advanced video games. Introduction is scheduled for next fall in Japan, later in the U.S.

Project Reality, the competitor to Saturn being developed by Nintendo and its partner, Silicon Graphics, won't be based on CD-ROM but on a silicon cartridge jammed with memory, the two companies said in a surprise announcement. They said that the cartridge will provide the fastest access time currently available. "When it comes to speed, no other format approaches the silicon-based cartridge," said Peter Main, marketing vice president of Nintendo.

Nintendo said that its new cartridge-based format will have an access time "two-million times faster than that of current CD-ROM technology." As for CD-ROM, an engineering official of Nintendo said, "anything short of quad speed is too slow, and there is even a question there—quad might not be fast enough." Nintendo expects its Project Reality cartridges to be sold at prices under $70. The system itself could be priced at less than $250 when it arrives on retailers' shelves late next year.

• Digital VCR soon. Home digital VCR's could be on dealers' shelves as early as next January, according to a knowledgeable industry source. A committee of 10 major manufacturers is working to develop a single standard, and all major decisions could be completed this spring or early summer. It's still not clear whether—or when—the new digital format will replace the current VHS and 8mm standards in home VCR's and camcorders, but here's what you're likely to get when you switch your home recording to digital:

It will be a more compact machine that is capable of using two different size cassettes. The smaller one, measuring about the same as today's DAT cassette (which is smaller than an audio cassette) will be loaded with ¼-inch tape with evaporated metal coating. It will record (and play) for an hour in standard definition, or 30 minutes in high definition. The standard-speed tape can be played back through any NTSC, PAL, or SECAM television set. The high-definition version will be designed to be compatible with most HDTV systems, including the Japanese analog Hi Vision and the American Grand Alliance system. The small cassette will make possible camcorders more compact than today's 8mm. A larger size cassette—still smaller than today's VHS—will record for 4½ hours of programming in standard definition and one-half that in HDTV.

The standards are sufficiently advanced that Panasonic has developed a commercial and broadcast version of the VCR for electronic news gathering. Is compatible with the consumer machines.

• Compatible widescreen TV. Analog HDTV in Europe was delivered a death blow by the combination of the direct satellite broadcasters' refusal to adopt the MAC standards and the development of a digital standard in the United States. While Europe ponders what to do about HDTV, several German state broadcasters are using an ingenious system to deliver widescreen pictuers in full definition while viewers with standard PAL sets watch a normal letterbox transmission.

The Germans are broadcasting in the PALPlus system, which has the approval of most European broadcast authorities. While a letterboxed movie transmission normally would lose resolution to send the full-width picture, PALPlus fills in the missing details for viewers with special widescreen sets. In normal PAL 625-line transmissions, 576 lines are visible in the picture (the remaining lines in the vertical blanking area between pictures). However, when a letterboxed widescreen picture is transmitted, there are only 432 lines of vertical resolution because the picture doesn't fill the entire screen vertically.

In PALPlus, the vertical information normally lost is filtered from the picture before transmission and then transmitted invisibly in the black area above and below the widescreen image. A separate signal is transmitted during the vertical blanking interval to tell the receiver PALPlus is being transmitted. A widescreen PALPlus receiver displays the widescreen picture in full fidelity, occupying the full screen, while a conventional 4:3 ratio set shows the standard letterbox image with black bands above and below. Separation of the brightness and color (Y and C) information further improves the quality of the picture.

Transmissions have now started, and European consumer-electronics product manufacturers had indicated their intentions to offer widescreen PALPlus receivers, VCR's, and adaptors this year.

Continued on page 83

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This advertisement was not written by a countersurveillance professional, but by a beginner whose only experience came from viewing the video tape in the privacy of his home. After you review the video carefully and understand its contents, you have taken the first important step in either acquiring professional help with your surveillance problems, or you may very well consider a career as a countersurveillance professional.

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Q & A

Write to Q & A, Electronics Now, 500-B Bi-County Blvd., Farmingdale, NY 11735

MOTOR SPEED CONTROLLER

I've been experimenting with small motors and would like to know if you have a simple circuit to control a motor's speed. I tried using a potentiometer to vary the voltage but the results were no good since I had almost no control at low motor speeds. Can you tell me why that didn't work and show me what to do?—B. Debat, Hunter, NY

Small hobby motors made a big comeback when people started messing around with robotics. They're great for trying out ideas before you go and drop bigger bucks for bigger motors. Unfortunately, the motors have fairly high hysteresis, so rheostat-type speed controls don't work very well.

There are two basic kinds of motors. The more popular (and cheaper) ones are controlled by voltage, but others (found in tape recorders, and turntables) are likely to be frequency controlled.

Most speed-control circuits for DC motors vary the voltage, but that's a terrible way to do the job because it causes motor hang up at slow speeds. This is the problem you encountered when you tried using a simple rheostat-type control. In order to start the motor, you have to get the voltage high enough to overcome the hysteresis of the motor as well as any sluggishness due to friction—don't forget that cheap motors are always, by definition, cheaply made.

The circuit in Fig. 1 varies the duty cycle rather than the voltage. The two diodes will provide individual control of the positive (D1) and negative (D2) halves of the capacitor's charging cycle even though the frequency stays the same.

The frequency can be approximated closely by:

$$f = 1/1.4RC$$

where R is the total resistance of the potentiometer. The remaining four inverters in the package are

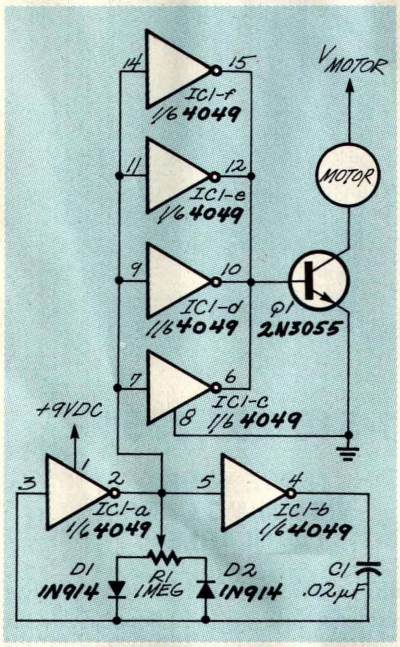

FIG. 1—THIS CIRCUIT VARIES the duty cycle rather than the voltage. The two diodes control of the positive and negative halves of the capacitor's charging cycle.

paralleled to increase the drive of the circuit because a single CMOS inverter doesn't have much output power. Use a 4049 inverter because it can produce substantially more power than most other CMOS inverters can.

The circuit in Fig. 2 should be familiar since it's just a basic oscillator made from a 555. It's one of the easiest circuits to build, and is perfectly suited to controlling small motors. What makes this circuit ideal for your purposes is the tremendous amount of drive capability inherent in the chip. The 555 can sink or source several hundred milliamperes so it should be able to supply current to the motors that you are likely to find in small recorders and turntables.

The values shown in Fig. 2 will let you vary the output frequency from 10 Hz to 100 Hz. If you want to experiment with component values, all you have to do is plug numbers into this formula:

$$f = 1.44/(R1 + 2R2)C$$

and wire in the appropriate components. Note that the duty cycle will increase as the frequency increases. This helps when you're controlling motor speed because low-speed response is a lot smoother if the clock has a higher on time.

TONER REFILL

I recently got a laser printer and, although it's a lot better than my old dot-matrix printer, I'm put off by the cost of a new toner cartridge. I've seen ads from suppliers that will sell me a refilled cartridge (with an exchange) for substantially less than the cost of a new cartridge. It's an attractive offer, but I'm concerned that the refill will damage my printer. Is it safe?—D. Katz, Great Neck, NY

This is a "When did you stop beating your wife?" type of question. No matter how I answer it, people are going to beat me up.

For the record, I don't believe in refilling toner cartridges since the savings are, as far as I'm concerned, nowhere near what you have referred to as "substantial." Life is tough enough, so if paying $10 to $15 extra can eliminate any single worry, I consider it money well spent. If you can afford the printer in the first place, you should be able to afford a new toner cartridge when you need one.

If toner cartridges had to be re-

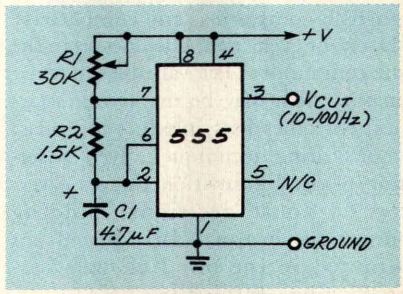

FIG. 2—THERE'S A TREMENDOUS amount of drive capability inherent in the 555; it can sink or source several hundred milliamps.

placed as often as the ribbons on your old printer, I'd be first in line to take a closer look at refilling them, but that's not the case. Unless you spend all your time printing high-resolution pictures of the night sky, a typical toner cartridge will last a long time. If you're using the printer as the main workhorse on a network, you should also look at alternatives to new toner cartridges, but the key word here is "look." See what the company offers as a guarantee before you sign up, because the cost of repairing a laser printer is substantially more than the savings you will get on the toner cartridge.

This whole business is similar to the issue of punching a hole in low-density floppy disks to save the cost of high-density ones. The people who do this swear there's no difference in the disks with a fervor equal to that of the people who swear that there is a difference. You can make up your own mind.

The bottom line here is that whatever you decide to do about toner cartridges, check the guarantee on your printer. I'm willing to bet that it contains a provision to void the guarantee if anything other than "authorized" cartridges are used.

IDENTIFIYING CAPACITORS

I'm just getting back into electronics after a few years absence, and I have a question about capacitors. Can you explain the identification system that uses numbers such as 104, 823, 103. I don't know where the system came from, but it sure is confusing. Any help you can give me will be appreciated.—J. Zyla, Raymond, MT

I'm the first to admit that there are some things in electronics that were designed by people whose elevator doesn't go to the top floor, but I'm sorry to say that this isn't one of those things. Although you didn't indicate it in your letter, aside from the three numbers, a fourth one—a letter—is also part of the group. A typical number that you might see written on a capacitor would be something like "104M" which would indicate that the capacitor is a 0.1μF part with a 20% tolerance.

Here's how it works. The first grouping is made up of the first two numbers. In the previous example that would be "10," which give you the integer portion of the value in picofarads. The second group is the third number and that is the multiplier's exponent. The "4" in this example would indicate that the multiplier factor is 10 to the fourth power. The last group (the letter) is the tolerance, and an "M" indicates that it would be 20%.

The value of the part is then 10×10^4 picofarads, which can be written as 100,000 pF. Because the "pico" suffix means 10^{-12}, it would actually be 0.0000001 Farad, or 0.1 μF. The whole system is straightforward, and the only arbitrary assignments are for the tolerances. For the record, therefore, J = 5%, K = 10%, M = 20%, and Z = +80/−20%. We've taken care of the number system, but I'm still looking for someone who can tell me how to read or where to find a complete explanation of all the capacitor color codes. Now *there's* a mystery. Ω

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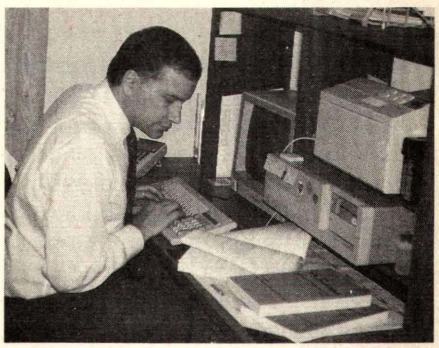

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LETTERS

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BATTERY INTERNAL RESISTANCE

I'm writing about T. Ng's letter in *Q&A* (*Electronics Now*, February 1994) in which he sought a simple way to measure the internal resistance of a nickel-cadmium battery.

A cell or battery's internal resistance is a good indicator of the energy left in the cell or cells; as the battery is used, its internal resistance increases. The internal resistance of an AA cell, for example, is about 10 ohms when it is fresh.

The quickest way to measure internal resistance is to measure the cell or battery's open circuit voltage and divide that value by the measured short-circuit current:

$$R_i = E_{oc}/I_{sc}.$$

But that current drain can kill the ammeter rapidly.

Another way to do it is to place about a 10-ohm load resistor (R_L) across the battery and measure the load voltage (V_L). R_i can then be calculated from:

$$R_i = R_L(E_{oc}/V_L - 1)$$

It can be seen from this equation that if the load resistor is equal to the battery's internal resistance, the load voltage is half the open circuit voltage. A low-impedance voltmeter can make the measurement.

I can't provide information on other kinds of batteries because I haven't experimented with them. If you measure the short-circuit current, do it quickly—in about a second! That's long enough to read the ammeter, without wasting the battery's energy.

CHARLES WOLF
San Francisco, CA

TRAFFIC LIGHT SEQUENCING

After I acquired a highway traffic signal light, I wanted a circuit that would make it switch colors in the same sequence as the real thing. I remembered seeing a circuit that would do this in "Ask R-E" in the February 1991 *Radio-Electronics*. I dug through my back issues and, sure enough, there it was.

There were several things I didn't like about the circuit, but the main one was its timing sequence. Instead of turning on the red and green lights for 30 seconds and the amber one for 4 or 5 seconds, they all turn on for the same length of time. I knew there must be a simple way to make it sequence like a real signal light.

The 4017 decade counter in the "Ask R-E" schematic drove the relays directly. My alternative solution is shown in Fig. 1. The only relays that I had whose coil current were low enough (sensitive enough) to be triggered by the 4017 were unsatisfactory. Every time the contacts would try to close to complete the circuit, the spark produced would foul them up and they wouldn't work.

At the time my load current through a 100-watt lamp filamant was about 800 milliamperes. I found that a small 5-volt Radio Shack relay with contacts rated at 2 amperes worked best. This meant, however, that I had to put transistors (2N2222) at the outputs of the 4017 to drive higher current relays. Diodes 9 to 14 keep the circuit from false triggering as the relays turn off.

I then solved the sequencing problem by connecting pin 3 (Q0) to the base of Q1 via R3, and connecting pins 2, 4, 7 and 10 (Q1 to Q4) via diodes D1 to D4 and R4 to the base of Q2. Similarly the next four pins drive Q3.

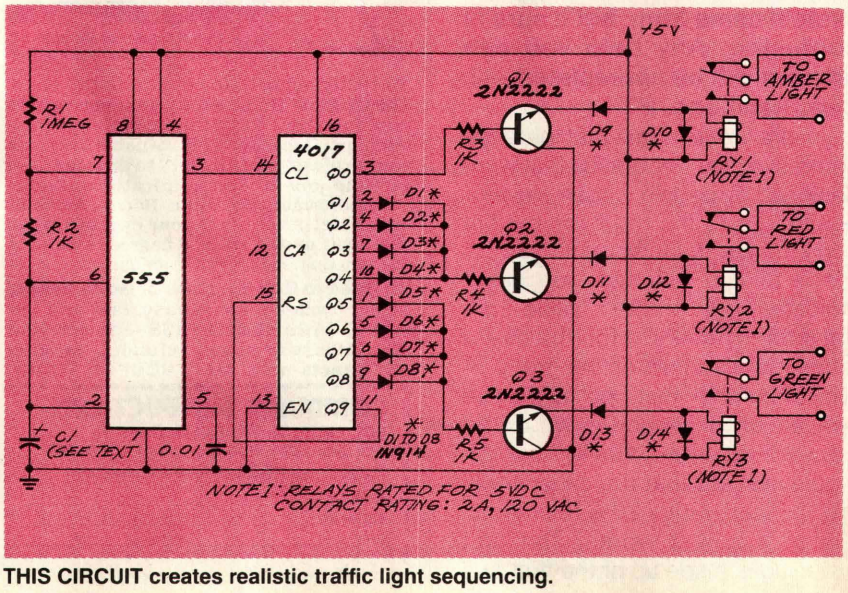
I found the best results with a C1 of 8 μF. That gives the 4017 a pulse about every 5 seconds. As a result, the amber light is on for about 5 seconds and the red and green lights are on for 20 to 25 seconds each. Diodes 1 to 8 prevent the tied outputs from trying to drive themselves.

I hope someone else out there has a practical application for this circuit. I've already mounted my traffic light, and it's going straight to my dorm room at school!

JOEL PEAVY
Fontana, CA

SAFE CONTACT CLEANING

I am writing about "Dangerous Cleaner," (*Q&A*, *Electronics Now*, February 1994). As the president of leading manufacturer of chemicals for electronics, I want to say that my company is willing to offer general advice about any chemicals used in electronics.



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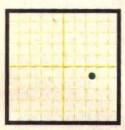

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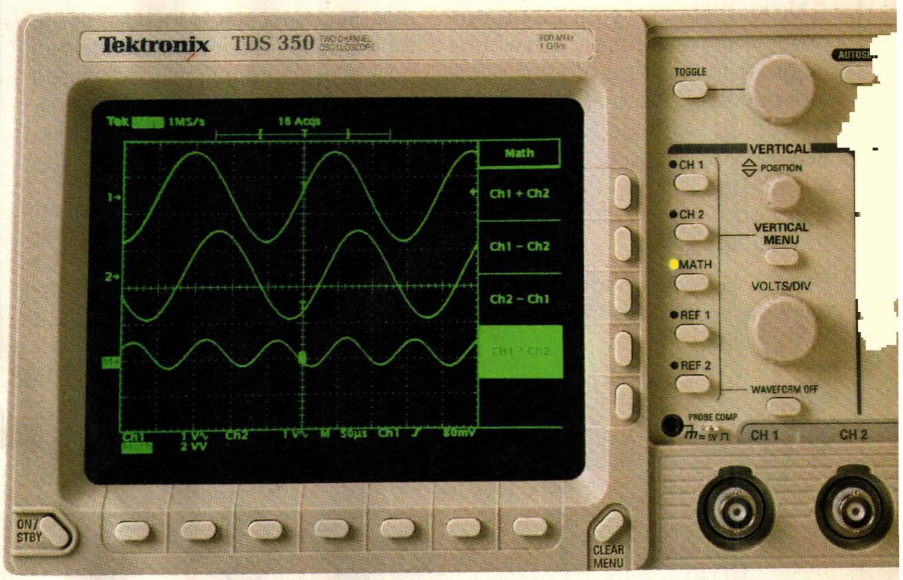

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Because of environmental pollution concerns, all chemical manufacturers have had to reformulate most of their aerosol sprays. In the past, Freon TF was the standard agent for cleaning PC boards, and it also served as the carrier solvent for tuner and contact cleaners—with or without lubricants.

Freon TF is an ideal solvent because it is not flammable, and it is compatible with plastics. The Environmental Protection Agency (EPA) has restricted the use of Freon. Unfortunately, all of the substitutes advanced so far have disadvantages. They are either flammable and evaporate slowly, or they attack and soften plastics.

The new EPA regulations have forced manufacturers to produce many different formulations that are application specific. In the past, only Freon TF could perform all those functions. Now there are from three to five choices, depending upon end-use application.

With specific reference to the quote from *Q&A* about "pushbuttons not working after applying a tuner cleaner," we can suggest a few possible reasons. First, the tuner cleaner might have contained a solvent that attacks plastics, causing swelling or tackiness.

Second, the formulation might have had a high alcohol content. (Alcohol is a conductive substance until it evaporates because it contains water.) On the other hand, the formulation might have contained a lubricant that is aggressive toward plastics. Silicone, a common lubricant in cleaners, is not a recommended lubricant because it will attack some plastics or elastomers it comes in contact with over an extended period of time.

Until the chemical industry produces a solvent whose characteristics match those of Freon TF, we suggest that you test all new cleaners before using them on any electronic hardware. Alternatively, you should contact the manufacturer for recommendations. Caig Laboratories (619-451-1799), for example, will be happy to answer your questions about its products.

MARK K. LOHKEMPER
CAIG LABORATORIES, INC.
San Diego, CA

PRODUCT CORRECTIONS

Elantec was pleased to see our EL2210/2410/2211/2411 dual and quad video amplifiers mentioned in *New Products* (*Electronics Now*, February 1994). I should appreciate your passing on two corrections to your readers:

- The video amplifiers are made with Elantec's complementary bipolar (*not* biCMOS) process.
- Dual versions are available in 8-pin small-outline IC (SO-8) surface-mount packages.

PATRICIA MAYER
ELANTEC, INC.
Milpitas, CA

REMOVING ICs

Electronics Now Magazine often publishes article and reader letters describing various methods of removing IC's from printed circuit boards. However, I have come across a tool that takes the headache out of removing stubborn IC's from PC boards.

Ungar makes a "slotted bar desolder tip" (No. 6948) expressly for removing DIP IC's that heats all the IC's pins at once. Its threaded fitting screws onto typical soldering-iron elements.

The desolder tip is a metal block with two-slotted bars that make contact with the IC's pins. It will work with a 33 to 45-watt soldering-iron heating element. Avoid overheating the PC board because conductive traces are delicate. With the help of an IC puller or a flat-blade screwdriver, the IC can then be removed easily from the board

When removing IC's from multilayer boards with the tool, pull the IC out only when the solder has melted all the way to the top layer nearrest to the IC body. Be sure to remove the IC quickly before the solder cools and freezes the pins halfway out of of the board.

Desoldering braid can then be used to open any holes still closed with solder.

RICHARD L. ERHARDT
Sunnyvale, CA

COMBUSTIBLE GAS ALARM WARNING

Dave Williams, in his article entitled "Combustible Gas Alarm" (*Electronics Now*, July 1993), describes how reducing gases, such as methane, butane, propane, and carbon monoxide, can be detected with a tin-dioxide sensor-based alarm.

In that article the reader is advised to position the alarm near the ceiling because methane is lighter than air, and would therefore collect near the ceiling. However, in giving that advice, Mr. Williams did not point out that many reducing gases are *heavier* than air. Carbon monoxide, propane, and butane, for example, can accumulate at floor level to reach dangerous concentrations well before a ceiling-mounted alarm would be triggered.

In the interests of personal safety and the prevention of fires and explosions, please advise your readers of this fact.

R.C.S.
Excelsior, MN

LASER POINTER POINTERS

I own a slender, pen-type pointer with a solid-state laser for spot illumination during presentations and lectures. Its AAAA alkaline power cells expired, so I needed replacements. (They have diameters of about 5/16-inch.) However, I could not find them in my local stores.

However, I discovered a readily available source by opening up a 9-volt Eveready *Energizer* radio battery. I carefully cut into both end seams with diagonal cutters, and easily peeled back the battery's thin metal case. There are six AAAA-size, 1.5-volt cells inside.

The cells will fall out because they are held in position by the outer case. They can be used immediately, but you might want to polish their contact surfaces with a pencil eraser if they happen to be tarnished.

To the best of my knowledge, the *Energizer* brand 9-volt batteries are the only ones made this way. So don't try to take apart 9-volt batteries made by other companies. Moreover, I'd advise caution in using the *Energizer* cells because their cases might not be as rugged (and therefor as leak-proof) as those of the larger and more common AAA cells.

ALAN L. WOODMAN, W9RUV
Mt. Prospect, IL Ω

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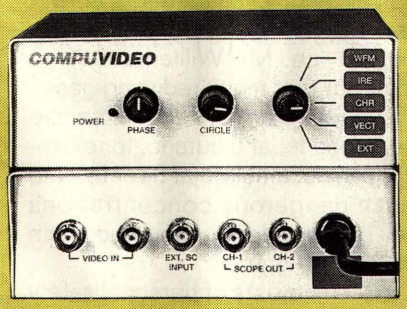

From video-production facilities to camcorder service centers, vectorscopes and waveform monitors are essential test and troubleshooting tools. However, technicians who cannot justify the expense of such specialized equipment for occasional use might find an attractive alternative in the model SVR-2000 from Compuvideo Products (3861 Oceanview Avenue, Brooklyn, NY 11224.) The SVR-2000 is a converter than turns virtually any two-channel oscilloscope into a vectorscope and waveform monitor.

The converter is packaged in a cream-colored metal cabinet that measures about 1½ × 3¼ × 5½ inches. Its rear panel contains five BNC jacks labeled VIDEO, VIDEO, CH-1 SCOPE OUT, CH-2 SCOPE OUT, and EXT. SC INPUT. Its front panel has a rotary PHASE control, a rotary function selector, and a CIRCLE toggle switch. No power switch is included on the unit. A graticule, like that shown in Fig. 1. is supplied with the SV-2000. It is placed over the oscilloscope graticule.

The SVR-2000 accepts composite video (1 volt peak-to-peak) at one of its rear-panel VIDEO jacks. The second VIDEO jack can be fed to a monitor or terminated in some other 75-ohm load. To use the unit as a vectorscope converter, its function switch is set to the VECT position, and its two outputs are fed to the channel 1 and channel 2 inputs of an oscilloscope. The oscilloscope should be set to its X-Y mode for proper operation, and the vertical amplifiers should be set for 0.2 volts per division. Although the converter is designed to operate at maximum accuracy with 6-foot connecting cables, they are not included with the unit.

The vectorscope display permits the color aspects of a video signal to be analyzed. In normal use, the unit is fed a video signal of color bars as defined by EIA standard RS189A.

Unlike a standard oscilloscope display, the vectorscope display is circular. That's because the vectorscope shows a polar plot of a video signal's 3.58 MHz chrominance subcarrier (which is actually two signals, modulated 90° out of phase on the same subcarrier). Amplitude increases outward from the center of the display, and the phase is measured around the circle.

In its vectorscope mode, the SVR-2000 displays chrominance amplitudes, aids in hue adjustments, and simplifies the matching of the burst phases of multiple signals. The latter is important in minimizing color shift when switching between video sources.

When the unit is fed a standard colorbar signal, the phase control must be adjusted so that the burst vector is at the 9 o'clock position. Each dot should fall on the cross hairs of the graticule's target boxes. (They represent the yellow, cyan, green, magenta, red, and blue bars in the colorbar signal.) Problems are indicated if they don't.

The vectorscope is valuable primarily as a setup tool. However, for monitoring live signals, a waveform monitor—which is basically an oscilloscope that has been tailored specifically to monitor composite video and sync signals—is far more

Continued on page 83

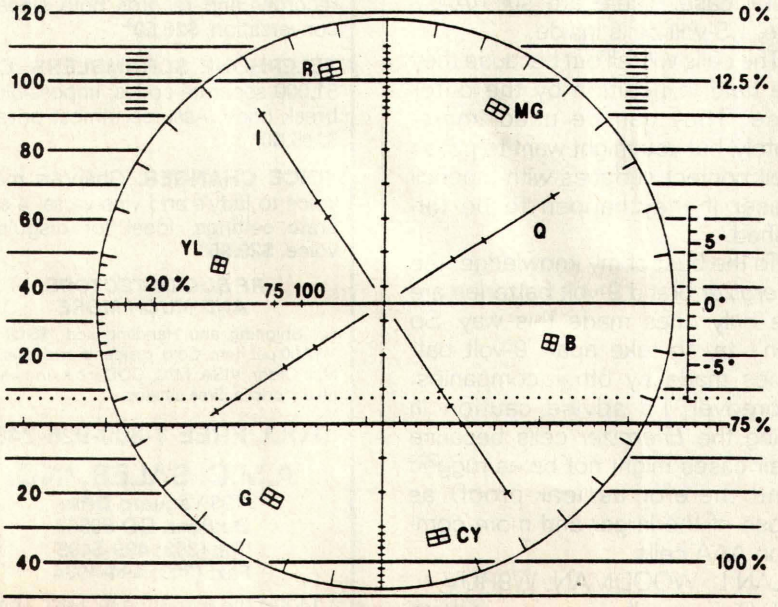

FIG 1—THE GRATICULE supplied with the SV-2000.

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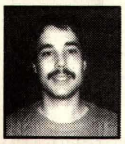

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Industrial Electrician
Ore-Ida Foods

"CIE was recommended to me by my boss. It was appealing since I could study at my own pace at home and during business travel."
Dan Parks
Marketing Manager/Consumer Products
Analog Devices, Inc.

"I loved the flexibility CIE offered. It was the only way I could continue both school and my demanding job."
Britt A. Hanks
Director of Engineering
Petroleum Helicopters, Inc.

"I liked the way the school was set up with laboratory assignments to enforce conceptual learning. The thing which impressed me the most about CIE's curriculum is the way they show application for all the theory that is presented."
Daniel N. Parkman
Missile Electro-Mechanical Technician
U.S. Air Force

"Completing the course gave me the ability to efficiently troubleshoot modern microprocessor based audio and video systems and enjoy a sense of job security."
Tony Reynolds
Service Manager/Technician
Threshold Audio & Video

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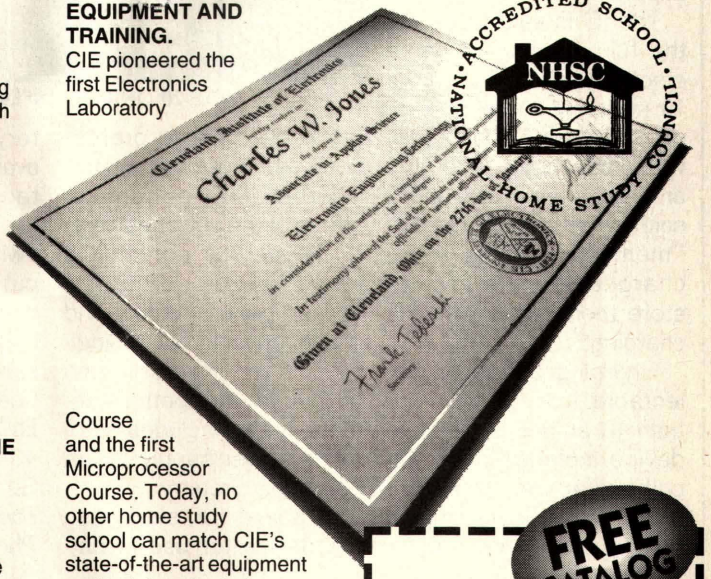

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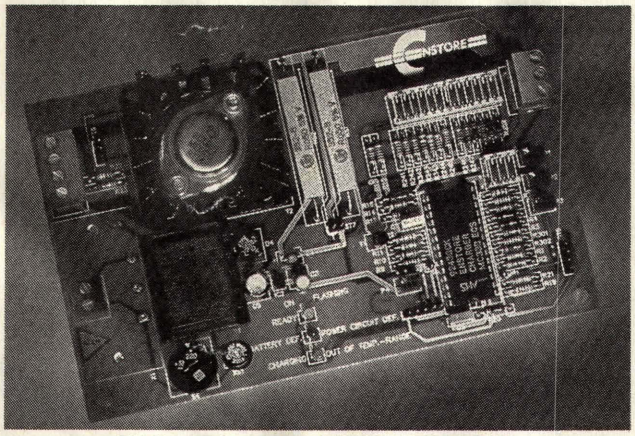
BATTERY-CHARGING IC. The *Enstore ECS-II(Electrode-Specific Charging System)* is a CMOS LSI integrated circuit for controlling the recharging of rechargeable cells and batteries. It is recommended as a component in battery-charging equipment, and it can drive a switched power supply.



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The IC is said to permit the full charging of some electrochemical systems in 10 minutes. It can be programmed for 1 to 20 cells with a capacity of 400 milliampere hours (mAh) and is said to be able to remove "memory" effects in rechargeable cells and restore them through trickle charging.

Charging current is selectable from 2 to more than 10 amperes. The LSI device includes short-circuit protection, and automatic battery insertion and polarity detection. Automatic overcharge protection is achieved by monitoring the electrochemical status of the cell or battery.

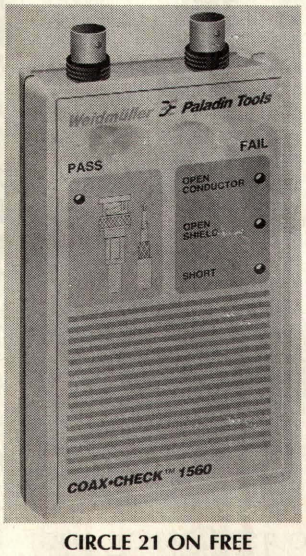
The device contains a temperature and battery voltage-control circuit, and it can drive LEDs to indicate battery insertion, end of charge, and battery defects. It also includes automatic power supply failure detection circuitry.

A board for evaluating the device for use in battery-charging systems is available. It includes an integrated circuit, provision for AC or DC input, and switch-programmable output for charging nickel-cadmium, nickel-metal hydride, and lead-acid batteries. The evaluation board is priced at $350.

EnChip, Inc.
434 Ridgedale Avenue
Suite 11-327
East Hanover, NJ 07936
Phone: 201-328-2049

COAXIAL-CABLE TESTER. The *Coax-Check* is an instrument designed to provide pass or fail analysis on RG-58, RG-59, and RG-62 coaxial cables. It tests the continuity of both the conductor and its braided shield. In addition, the tester identifies short-circuits resulting from contact between the conductor and the shield.

A "pass" diagnosis is indicated when a green LED led lights up, and a "fail" diagnosis is indicated by the lighting of one or more of the red LEDs that indicate a reason for failure.



CIRCLE 21 ON FREE INFORMATION CARD

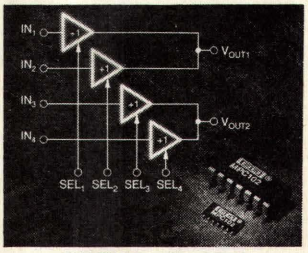
The tester is housed in a rugged instrument case and is supplied with a 9-volt battery that is installed.

The *Coax-Check 1560* is priced at $35.67.

Weidmuller Inc./Paladin Tools
3543 Old Conejo Road,
Suite 101
Newbury Park, CA 91320
Phone: 800-272-8665

DUAL 2-1 VIDEO MULTIPLEXER. The *MPC102* from *Burr-Brown* is a dual, wide-bandwidth, 2-to-1 channel video-signal multiplexer. It includes four identical, monolithic, open-loop buffer amplifiers. Two buffer outputs are each internally connected at the output. Its bipolar complementary buffers form a unidirectional transmission path that offers high output-to-input isolation.

The *MPC102* is primarily intended to route video signals for wide-bandwidth systems, including HDTV and broadcast equipment. However, it also has applications in radar, telecommunications, computer graphics, and data-acquisition systems



CIRCLE 22 ON FREE INFORMATION CARD

One of its two input signals can be connected to the corresponding output. The output of the multiplexer is in a high-impedance state when no channel is selected. When one channel is selected with a digital "1" at the corresponding SEL input, the component acts as a buffer with high input impedance and low output impedance.

Bandwidth is specified as 210 MHz (1.4 volts p-p), slew rate is 2 volts p-p and interchannel crosstalk is 68 dB (30 MHz).It can also serve as a 1 to 2 demultiplexer, a 2 to 1 multiplexer for ECL data, and a 2 to 1 multiplexer for differential analog signal processing applications.

The *MPC102* is available

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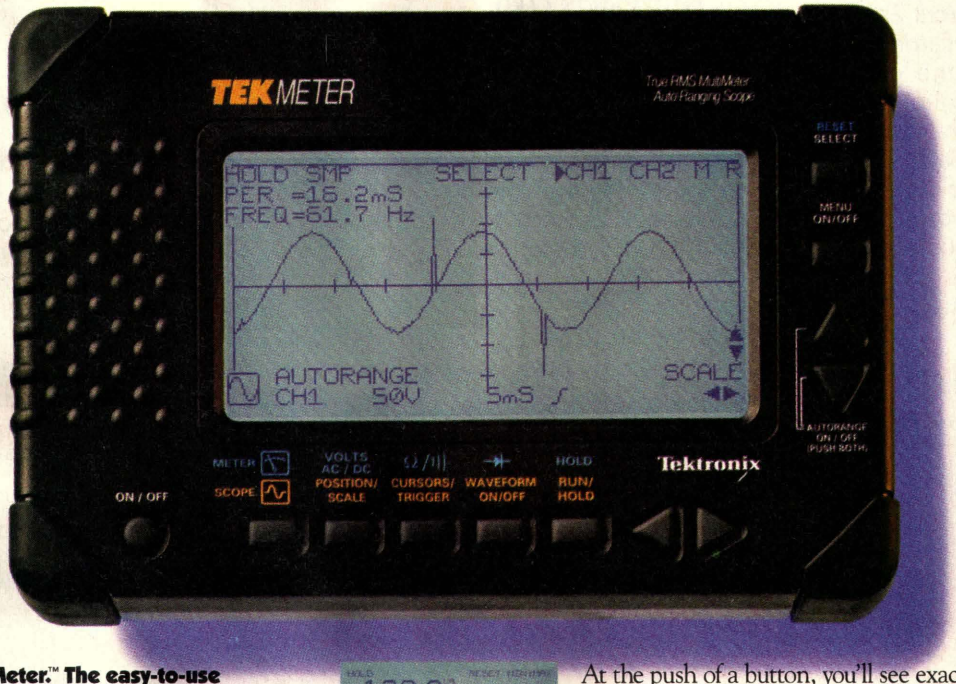

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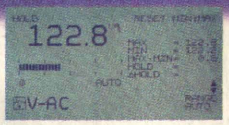

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Of course, the best way to take full measure of TekMeter is to try it for yourself. For the name of your nearest authorized Tektronix distributor, call 1-800-426-2200, ext. 800 and put one to the test.

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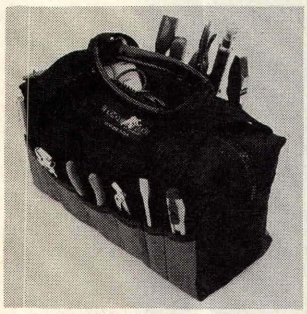
in 14-pin plastic DIPs, SOICs, and as dice. Pricing is from $7.41 each in quantities of hundreds.

Burr-Brown Corporation
P. O. Box 11400
Tuscon, AZ 85734
Phone: 800-548-6132

SOFT-SIDED TOOL BOX. The *Tool Tote* from *Paktek* is a fabric tool carrier, an alternative to the metal tool box. Made from 1000-denier Cordura, it is intended to eliminate possible damage to furniture and equipment caused by metal tool boxes that are carried to the site for field maintenance.



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The tool carrier has an oversized opening that makes it easy to find and replace large tools, and it also has fourteen outside pockets for smaller tools. Styled in red-and-black, the tote bag measures 7.5 × 7 × 14 inches.

The *Tool Tote* is priced at $24.97.

Paktek Inc.
7307 82nd St. Ct. SW
Tacoma, WA 98498
Phone: 800-258-8458

CABLE-BUNDLING TIE. *Kurly-tie* cable wraps permit fast, neat storage for probe and test leads. Each tie wrap includes a locking tie to secure it to the cable. The rubberized plastic coil expands to bundle cables, but when removed it contracts to a small size to stay out of the user's way. The cable wraps are available in

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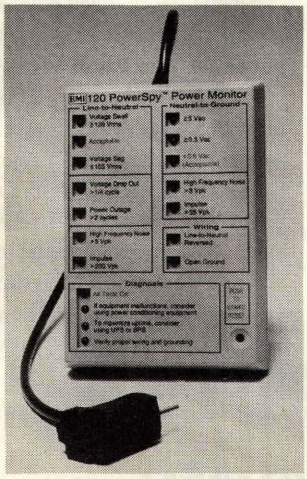
16 colors. The wraps also can hook onto nearby hardware for convenient positioning of the cable.

A pack of *Kurly-tie* cable wraps containing one in each color is priced at $10. Add $2 S & H. A sample is priced at $1.

SuperVid Supply
3382 Border Drive
Stone Mountain, GA 30087
Phone: 404-413-8624

POWER MONITOR. *BMI's 120 PowerSpy* is a portable power monitor that detects wiring errors and power disturbances on line-to-neutral and neutral-to-ground voltage. The monitor is plugged between the sensitive load and the outlet. The monitor also detects sags, swells, impulses, waveshape faults, high-frequency noise, and power failures.



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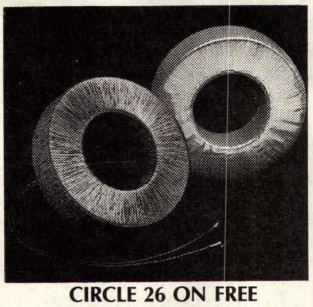
A display of LED lamps on the front panel of the handheld instrument indicates power disturbances and a diagnosis. If a power disturbance occurs, a latching red LED lights and remains on until the reset button is pressed. Simultaneously, appropriate diagnostic LEDs light to suggest a remedial actions. If power fails, the monitor stores the last LED settings for 48 hours.

The *PowerSpy* power monitor is priced at $545.

Basic Measuring Instruments (BMI)
3250 Jay Street
Santa Clara, CA 95054
Phone: 408-970-3700

CUSTOM TOROIDAL POWER TRANSFORMERS. Custom transformers that are made so they do not vibrate and generate humming or buzzing sounds are being offered by GFS manufacturing. The company says that its improved winding machines and a vacuum chamber make this feature possible.



CIRCLE 26 ON FREE INFORMATION CARD

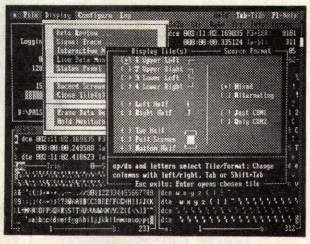
In the vacuum impregnation process, varnish penetrates the windings, displacing air trapped under the insulating tape. This is said to prevent the coils from vibrating under the influence of the applied AC so that no noise is emitted. It also protects the windings from damage.

Transformers made with this method are recommended for applications where acoustic background noise must be eliminated: hi-fi audio power amplifiers or in laboratory equipment for performing acoustic tests.

Custom toroidal power transformer from GFS range in price from $20 to $150 each, depending on size and rating.

GFS Manufacturing, Inc.
140 Crosby Road
Dover, NH 03820-4371
Phone: 603-742-4375

MONITOR/COMMUNICATIONS DEBUGGER SOFTWARE. *Paladin Software* is offering its version 3.0 *MicroTAP* (formerly DataScope) asynchronous communications debugging, data-capture and analysis software. This capability makes it a cost effective alternative to expensive hardware line monitors, according to its publisher.



CIRCLE 27 ON FREE INFORMATION CARD

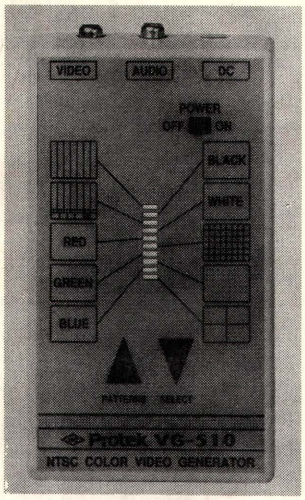
MicroTAP includes context-sensitive Hypertext, HyperAccess, user-alterable, multitasking window displays, and oscilloscope-like signal event tracing. All data and signal events are time-stamped to the nearest microsecond.

Version 3.0 adds EGA/VGA font maps with an integrated font-map editor, a Hypertext reader with direct links to program setup fields, expanded log capacity, and PostScript file exportation feature.

MicroTAP version 3.0, including cables, connectors, and manual, is priced at $349.

Paladin Software, Inc.
2945 Kenosha Avenue
San Diego, CA 92117
Phone: 619-490-0368

HANDHELD VIDEO TEST GENERATOR. The handheld *Model VG-510* NTSC video and audio generator from *Protek* provides ten test patterns: SMPTE; black burst; full-field color bars; red, green, blue, and white fields; center pulse cross; dots; and cross hatch. It is for maintenance of video equipment and video editing.



CIRCLE 28 ON FREE INFORMATION CARD

The generator measures 5½ × 3¼ × 1½ inches and weighs 7½ ounces without power cells. Audio output is 1 kHz with an adapter included for 120-volt studio use. Four AA cells will power the generator for more than 40 hours.

A VG-510 generator that does not offer SMPTE bars is priced at $299; if it does, the price is $399. A model that provides S-VHS output is priced at $549. Options include RF output, rechargeable battery, and a PAL standard version.

HC Protek
154 Veterans Drive
Northvale, NJ 07647
Phone: 201-767-7242

UNIVERSAL IC PROGRAMMER. *Xeltek's Superpro/EM* universal IC programmer can program field-programmable memory and memory in some micro-

CIRCLE 29 ON FREE INFORMATION CARD

controllers and programmable logic devices (PLD).

The memories that can be programmed include EPROMs, EEPROMs, and Flash EPROMs with capacities to 8 Mbits, microcontrollers from Intel, Motorola, Signetics/Philips, Zilog, AMD, Hitachi and National Semiconductor. It can also program some PLDs such as the 16V8 and the 20V8 PALs and GALs.

The included software is menu driven and said to be easy to use. It includes a comprehensive library for programmable ICs. Macro and batch functions permit single-keystroke automated programming. As new devices are added to the library, software upgrades will be available fre to customers through a 24-hour BBS service.

The *Superpro/EM* IC programmer is priced at $399.

Xeltek
757 North Pastoria Avenue
Sunnyvale, CA 94086
Phone: 408-524-1932

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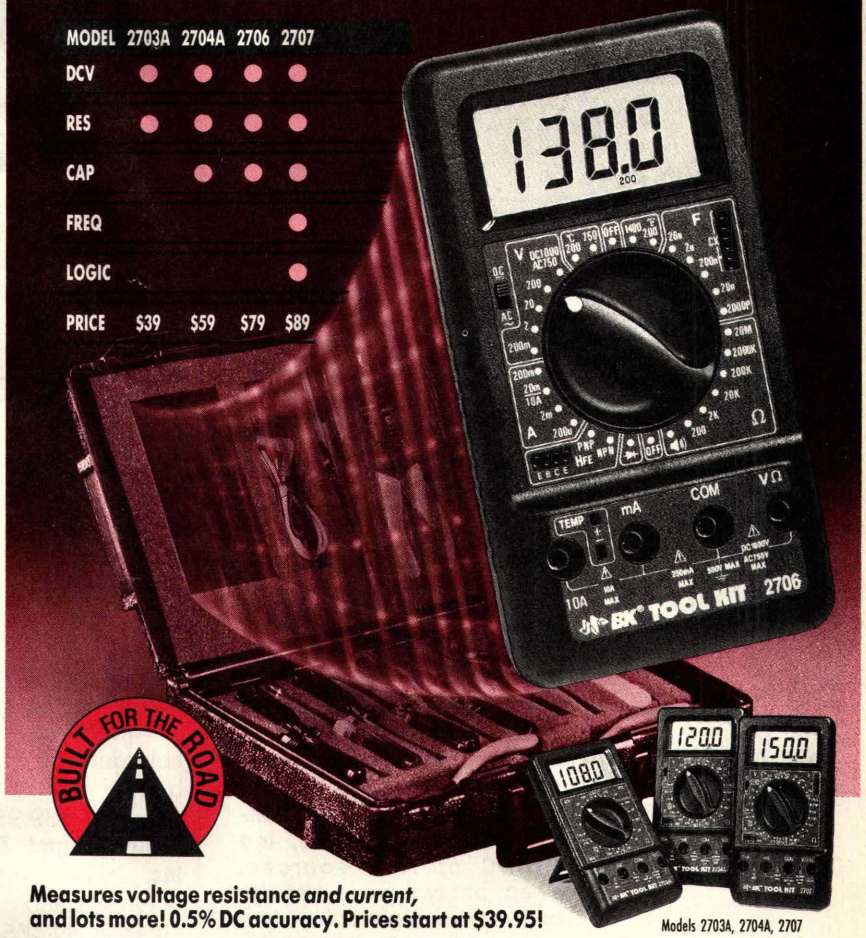

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MAGNETIC-FIELD DETECTOR. The *MFD-1* low-level magnetic-field detector can detect both the strength and the direction of many low-level electromagnetic fields. Its manufacturer, *Environmental Electronics, Inc.* says it is suitable for performing the tests that seek to correlate the effects of electrical fields on human health.

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The detector measures field strengths from 0.25 to 57 milliGauss. As a result of its 20 Hz to 10 kHz bandwidth, it can measure extremely low frequency (ELF) and very low frequency (VLF) fields. The display of the handheld instrument is a ten-segment LED bargraph with two ranges, and it has a power on/off switch state indicator.

The detector is in a case that measures $1 \times 2\frac{5}{8} \times 6\frac{11}{16}$ inches, and it weighs 7 ounces with the battery.

The *MFD-1* magnetic-field detector with a 9-volt battery and instructions is priced at $39.95.

Environmental Electronics, Inc.
P. O. Box 980
Goshen, IN 46527
Phone: 616-641-7645

UTILITY SERVICE DIGITAL MULTIMETER. The *HD165* digital multimeter from *Wavetek* is intended for low-impedance AC voltage measurements on high-voltage power lines. This multimeter is said to eliminate "ghost images"—voltages that contain no real power. They occur when voltage from a powered line magnetically induces voltage into non-powered lines.

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The low input impedance (low Z) of the HD165 eliminates ghost voltage readings. The transient limit in the HD165 is 10 kilovolts. Limiting the DMM to AC voltage measurement eliminates the possibility of measuring voltage with the leads in current input jacks. Readings are indicated on a 10,000-count (0.1 to 999 volt) display for the best resolution at higher voltages.

The rugged and contamination-proof DMM is intended for use by persons doing field maintenance for public utilities, industrial power plant maintenance, and at power-generation and distribution stations.

A protective holster protects the meter from drops and a tilt stand gives two viewing angles.

The HD165 DMM with battery, test leads terminated by alligator clips, protective holster, tilt stand, and operator's manual is priced at $279.

Wavetek Corporation
9145 Balboa Avenue
San Diego, CA 92123
Phone: 619-279-2200

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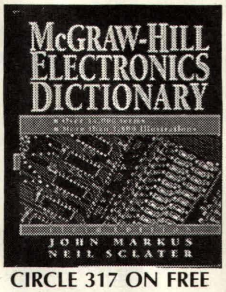
McGRAW-HILL ELECTRONICS DICTIONARY, FIFTH EDITION; by John Markus and Neil Sclater. McGraw-Hill, Inc., 1221 Avenue of the Americas, New York, NY 10020; Phone: 800-2-MCGRAW; $49.50.

The language of electronics is changing almost as fast as the technology. New words, phrases, and acronyms are being coined continuously, even as older terms change in meaning while others fall into disuse. It is difficult even for professionals to keep up to date in the language of electronics because of its many specialties—computer, telecommunications, consumer entertainment, and military/aerospace, to mention but a few. While sharing a common vocabulary, each has its own set of specialized terms.

The McGraw-Hill Electronics Dictionary provides clear, precise definitions of thousands of words and phrases as well as the derivations of many acronyms and abbreviations. It defines the latest terms as well as those classic terms that remain the hard care of the language of electronics. Many obsolete terms have been retained because of their historical significance.The dictionary will help you to understand the latest technical articles, books and advertising copy.

This is the Fifth edition of a dictionary that has served as the definitive reference on electronics language since it was first published almost 50 years ago. The



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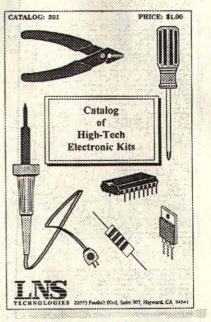
first four editions were prepared by the well known author of electronics books, John Markus. This fifth edition has now been completely revised and updated by **Electronics Now** Associate Editor, Neil Sclater.

The addition of 1200 new entries and 150 new illustrations, reflect the changes that have occurred in the industry since the fourth edition was published 20 years ago. It now contains more than 14,000 terms and 1100 drawings. The additions include definitions of such terms as CD-ROM, fiber optics, fuzzy logic, laser printer, multimedia, and neural network. Many earlier definitions have been thoroughly revised and expanded to reflect the many changes that have occurred as a result of technological advancements and new applications.

All of the entries are arranged alphabetically, with abbreviations, acronyms, and phrases treated as single words. Cross-referencing makes it easy for the user to quickly find synonyms and related topics. The dictionary also presents the SI units of measure with exact definitions and abbreviations.

High-Tech Electronic Kits Catalog No. 301; from LNS Technologies, 20993 Foothill Blvd., Suite 307, Hayward, CA 94541; $1.00 (refundable with order).

This 18-page catalog is filled with listings of easy-to-build electronics kits that have been designed both for the enjoyment of building them and their educational value. The wide assortment of kits listed in the catalog include those for building lasers, solid-state recorders, voice changers, gas sensors, motion detectors, and the application of microprocessors.



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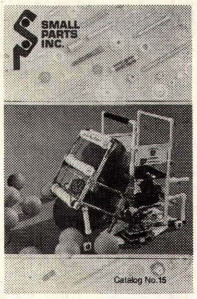
Each kit is rated with a skill level from beginner to advanced. Accompanying each kit is a detailed, illustrated assembly manual that helps the builder identify each part, provides a schematic diagram, and explains how the finished project works.

1994 Catalog No. 15; from Small Parts Inc, 13980 N.W. 58th Court, P. O. Box 4650, Miami Lakes, FL 33014-8650; Phone: 305-558-1038; Fax: 800-423-9009; free.

This is a 320-page catalog of hard-to-get mechanical parts and materials in small or large quantities from Small Parts Inc. It is sure to appeal to hobbyists and students as well as professionals who have trouble purchasing high-tech specialty items and materials in small quantities



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Small Parts Inc. is one of the sponsors of the U.S. FIRST robotic competition; last year's winner is shown on the catalog's cover, and a special section within the catalog describes the exciting competition.

The products listed include stainless-steel tubing, wire, and fittings, gas springs, linear-motion slides, fiberglass structural shapes, spring-release hinges, and vibration and noise isolation components. The company offers free priority shipping on a minimum orders of $15

POWER UP! How to Make Battery Adapters for Portable & Military Radios & Other Military & Non-Military Electronics; by Dave Strom. CRB Research Books, Inc., P. O. Box 56, Commack, NY 11725; Phone: 800-656-0056 or 516-543-9169 outside the

continental U.S.; Fax: 516-543-7486; $13.95 plus $4 shipping and handling ($5 in Canada, NY state residents add $1.53 tax).

This book tells you how you can power surplus military radios and other field-portable equipment with readily available commercial batteries that will replace the hard, if not impossible, to get military spec batteries that were designed in. Inability to find battery replacements has discouraged many people from purchasing this durable, versatile, and easily operated equipment.

In Strom's book you'll learn how to assemble alternative power sources by making your own battery adapters for consumer aftermarket cells and batteries. Detailed instructions and clear wiring diagrams show how the adapters are loaded with batteries from Eveready, Duracell, Radio Shack, or other suppliers.

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Included are plans for adapters that, with batteries, will power portable and mobile radios, night-vision scopes, radiac sets, detection/intrusion sets, and field telephones. Appendixes include battery replacement charts, specifications, and a listing of leading military-surplus equipment sources.

Timing Solutions Data Book (BR1333/D); from Motorola Literature Distribution Center, P. O. Box 20924, Phoe-

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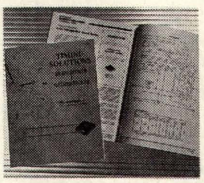
nix, AZ 85063; Phone: 800-441-2447 or 602-944-6561 outside the U.S.; Fax: 602-994-6430; free.

This 190-page book from Motorola discusses electronic devices for the distribution of clock signals. This edition has been expanded to include the latest information on Motorola's low-voltage PLL clock drivers, 5-volt PLL clock drivers, low-voltage/low-skew fanout buffers, and general-purpose clock-generation circuits.



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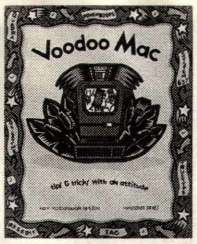
Included in the book are data sheets and applications notes on system design, clock-distribution techniques, and design with high-speed PECL logic. Motorola says it offers the industry's broadest selection of clock-distribution circuits with timing solutions for all of its logic technologies.

Voodoo Mac: Tips & Tricks with an Attitude; by Kay Yarborough Nelson. Ventana Press, P. O. Box 2468, Chapel Hill, NC 27515; Phone: 919-942-0220; Fax: 919-942-1140; $21.95.

This book takes a humorous, slightly irreverent approach to Macintosh computers. It sets out to demystify and enlighten Mac users at all experience levels so that they can have some fun while becoming more proficient and productive with their own Mac computers.

Ms. Nelson provides guidance on just about every subject of interest to



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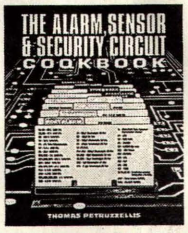
Mac users: startup, networking, customizing the keyboard, dialog boxes, and menus. You'll also find information on storing, erasing, and changing hard disks, printing and fonts, and increasing memory capacity. Diagnostic tips will help the Mac user avoid INIT/extension conflicts, use 32-bit addressing, recover lost files, understand error messages, and recover from a crash.

The Alarm, Sensor & Security Circuit Cookbook; by Thomas Petruzzellis. Tab Books Inc., Blue Ridge Summit, PA 17294-0850; Phone: 800-233-1128; $17.95.

This cookbook is a reference source of information on alarms and security circuits for everyone from professionals to students and hobbyists. It contains circuit diagrams and building instructions for a wide range of projects relating to home, office, and automotive protection.



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The projects include a multi-purpose, high-gain antenna, pressure sensors, vibration and heat sensors, smoke and toxic gas detectors, door and window alarms, motion and impact sensors, and a complete remote audio/video security and surveillance system. The author has built and tested all of the circuits, and they have proven effective in practical alarms, sensors, and security systems.

Electronic Parts & Components Catalog No. 32; from MCM Electronics, 650 Congress Park Drive, Centerville, OH 45459-4072; Phone: 800-543-4330; free.

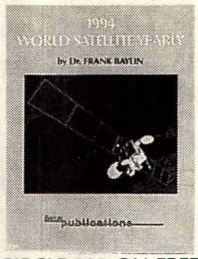
CIRCLE 324 ON FREE INFORMATION CARD

This latest edition of MCM's parts catalog contains 1000 new listings of electronic parts and components for a total of over 20,000. Among the product categories included are semiconductors, power supplies, home-security alarms, parts for TV sets, VCRs and telephones, connectors, tools, batteries, speakers, and test equipment.

1994 World Satellite Yearly; by Dr. Frank Baylin. Baylin Publications, 1905 Mariposa, Boulder, CO 80302; Phone: 303-449-4551; Fax: 303-939-8720; $90 plus $5 shipping and handling.

This book provides the kind of up-to-date information on satellite reception that fans need to determine satellite programming available at various receive sites. It also gives useful information on the equipment needed to receive that programming.

A technical section includes a detailed background on satellite broadcasting, the components for a home satellite system, and the methods for aiming a parabolic-dish receiving antenna. Also covered are broadcast methods and standards, complete tables of broadcast formats, compressed digital video and audio methods, and scrambling and encryption techniques.



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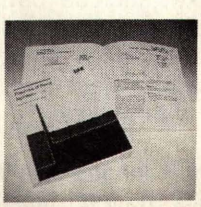
The programming section lists polarity, frequency, and language for video programming available on broadcast satellites. A 400-page satellites section presents the characteristics and footprints of every operational broadcast satellite, and a vendor's section gives a complete directory of satellite programmers and manufacturers.

Handbook of Power Signatures, Second Edition; from Basic Measuring Instruments (BMI), 3250 Jay Street, Santa Clara, CA 95054; Phone: 408-970-3700; Fax: 408-970-3720; $35.

This is a 290-page informative book on the identifying features, cause, symptoms, and solutions for the most common power disturbances. The



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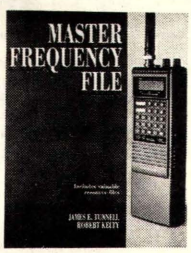
signatures were printed by the 4800 PowerScope, 8800 PowerScope, and 8010 PQNode power monitors.

This second edition includes updated and expanded information on simultaneous voltage and current monitoring, harmonics analysis, power quality surveying, safety practices, and report writing. It includes new tables, frequently-used equations, a glossary, and a recommended reading list.

Master Frequency File; by James E. Tunnell and Robert Kelty. Tab Books Inc., Blue Ridge Summit, PA 17294-0850; 1-800-233-1128; $29.95.

If you're interested in listening to shortwave radio broadcasts or monitoring the communications within and between government agencies—law enforcement or military—this book is for you. A scanner's delight, it identifies the services, frequencies, call signs, and user IDs on the VHF and UHF (25 MHz to 2.11 GHz) radio bands.



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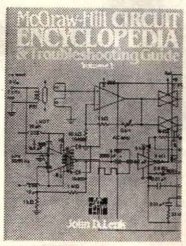
The listing contains the information you'll need to tune in and listen to conversations between such government agencies as the FBI, DEA, Secret Service, IRS, the Border Patrol. You will also be able to listen in on the Marshal Service, the Bureau of Prisons and the National Park Service. However, the regular broadcasts from NOAA will prove more helpful if you are planning trips by auto, airplane or boat.

Tunnell and Kelty's book contains a useful list of publications, organizations, institutions, and facilities that can provide you with further assistance in locating broadcast frequenies from sources of interest to you.

McGraw-Hill Circuit Encyclopedia and Troubleshooting Guide, Volume 1; by John D. Lenk. McGraw-Hill Book Company, 11 West 19th Street, New York, NY 10011; Phone: 1-800-2-MCGRAW; $59.50.

Lenk's guide contains a collection of more than 7000 of the latest, most widely used integrated and discrete component circuits. The schematics are accompanied by a step-by-step troubleshooting guide for solving problems related to applying those electronic circuits.



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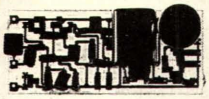
The circuits in this book have been tested and are known to work. Nevertheless, the reader with a knowledge of circuitry will be able to change certain component values to tailor the circuits to his specific needs.

Lenk explains how the circuits work and where you will find them in existing electronic products and systems. Included in the book are circuits intended for ultrasonic, intermedi-

Continued on page 68



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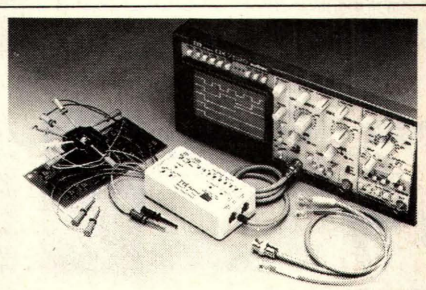

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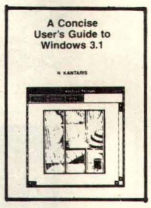

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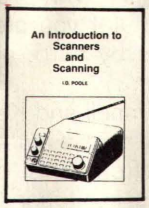

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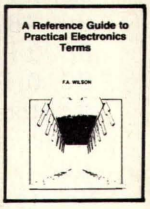

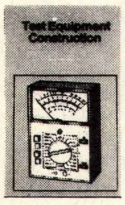

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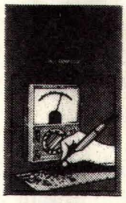

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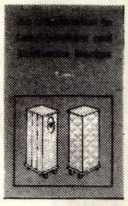

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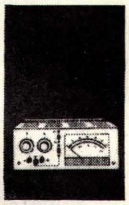

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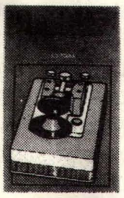

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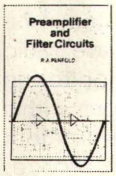

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Programmable Logic Devices

Make designing logic circuits easy with programmable logic.

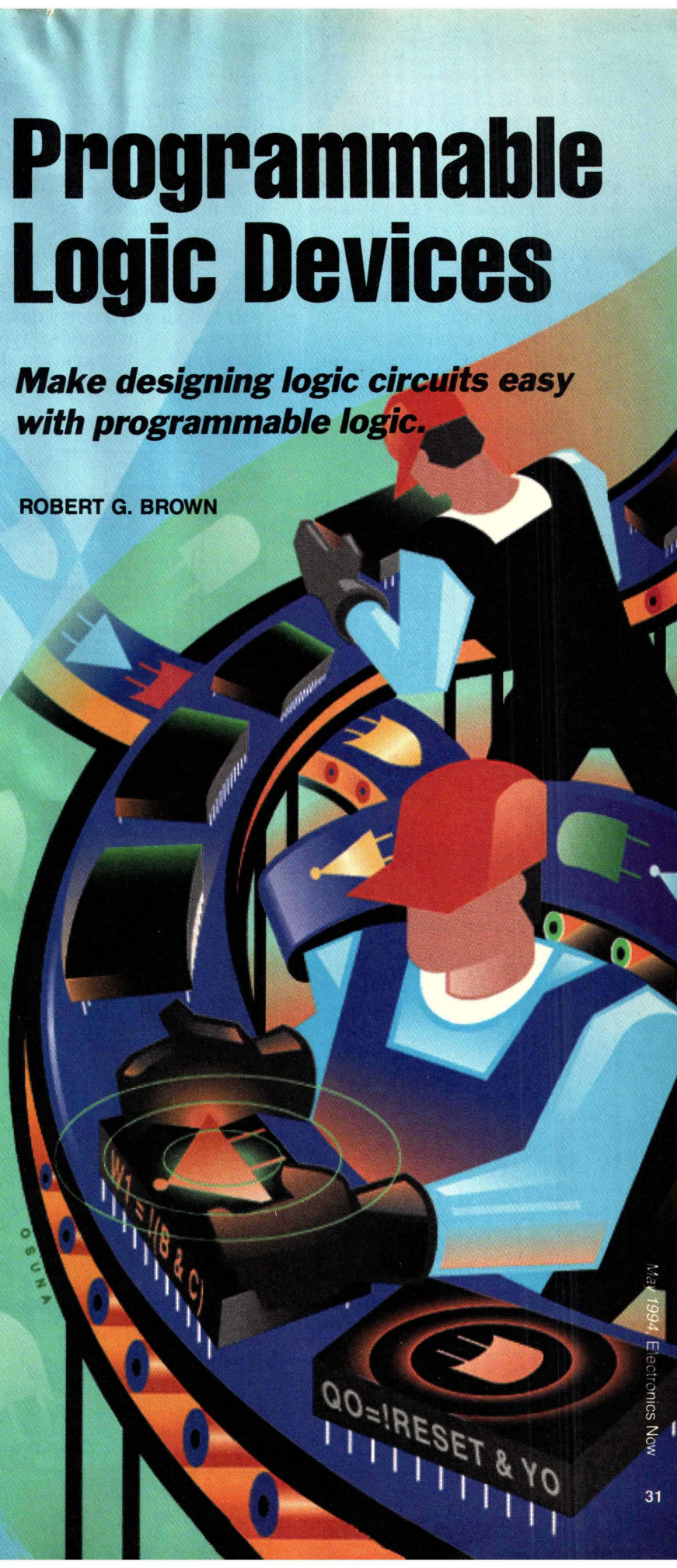
ROBERT G. BROWN

A PROGRAMMABLE LOGIC DEVICE, or PLD, is an unstructured array of AND and OR logic gates that can be organized to perform dedicated functions by selectively opening or otherwise altering the interconnections between the gates. In some PLDs, this is done by "burning out" fusible links , and in others it is done by reducing the conductivity of their interconnections by selectively applying overvoltage. PLDs can be considered as semi-custom logic devices because they stand between standard logic gates that cannot be altered and full custom-designed circuits. They are an extension of the technology first developed for field-programmable read-only memory (PROM).

The term PLD is a generic term that can be used by anybody, but terms such as PAL, FPLA, and GAL are better known. Those terms are proprietary designations that were given to the products by the manufacturer that developed them. For example, the programmable logic array (PAL) was developed by Monolithic Memories Inc., now a part of Advanced Micro Devices (AMD) and the field-programmable logic array (FPLA) or programmable array (PLA) was developed by Signetics, which is now part of Philips N.V.

The first PLDs were introduced as replacements for simple standard ICs with 4 to 100 gates. Today low-cost medium scale PLDs can replace four or more logic ICs.

The introduction of PLDs was a great boon to the field of digital hardware design. The second-generation PLD, the GAL (which stands for Generic Array Logic, a trademark of Lattice Semiconductor), is particularly



suited for the small-scale hardware designer. GALs offer the following benefits to the hardware designer:

- Flexibility—GALs are very flexible devices; they can implement both combinatorial logic functions (AND, OR, NAND, etc.) and registered logic functions (counters, shift registers, etc.) on the same chip.
- PAL replacement—The GAL16V8 and GAL20V8 each can directly replace over 20 of the common PAL types. This means you need to stock only two types of GALs to handle all your PLD needs.
- Space savings—Each GAL typically replaces between two and four standard TTL chips, saving a large amount of board space.
- Speed—GALs are fast devices with propagation delay down as low as 7 nanoseconds. Typical GALs have a propagation delay of only 15 nanoseconds—faster than standard 7400 or 74LS series logic.
- Reprogrammability—Not only are GALs programmable, giving the ability to correct design errors and make board layout easier, they can be reprogrammed up to 100 times. Erasing and programming takes only a few seconds.
- Cost—In addition to the savings in PC board real estate, standard speed GAL16V8s and GAL20V8s (25 and 15 ns) cost only a few dollars apiece, even in small quantities.

There are several varieties of GALs, but this article is limited to the GAL16V8 and GAL20V8. They are easy to design with and are the least expensive and most readily available GAL devices. Rather than get bogged down with the internal details of the devices, the article describes what's needed to use these PLDs in your designs and then looks at a practical design example.

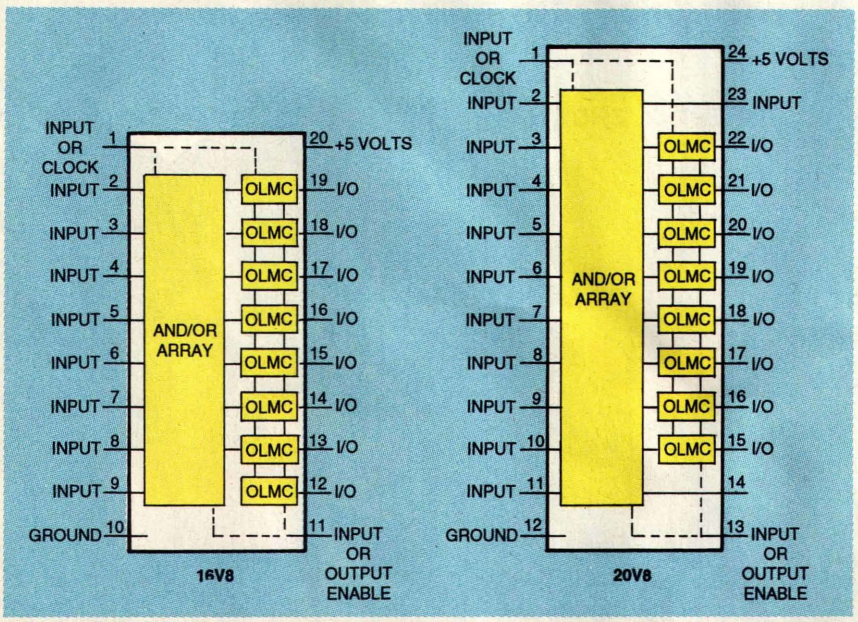


FIG. 1—THE GAL16V8 is commonly packaged in a standard 20-pin DIP, and the GAL20V8 is commonly packaged in a 24-pin skinny DIP.

Device architecture

The GAL16V8 is commonly packaged in a standard 20-pin DIP, and the GAL20V8 is commonly packaged in a 24-pin skinny DIP (0.3 inches wide—half the width of a standard 24 pin DIP). The pinout for both devices is shown in Fig. 1. For the GAL16V8, pin 10 is the

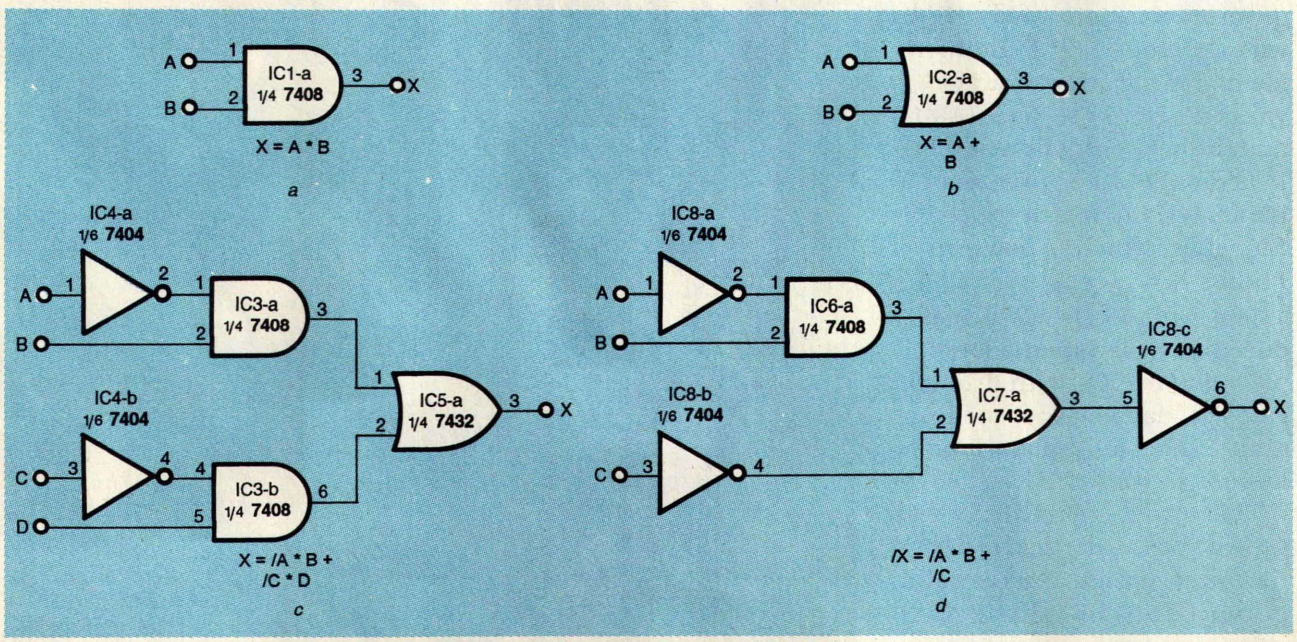


FIG. 2—THE EQUATION represented by an AND gate is shown in *a*, a 2-input OR gate is shown in *b*, and a more complicated array of logic is represented in *c*. Inversion can also occur on the output as shown in *d*.

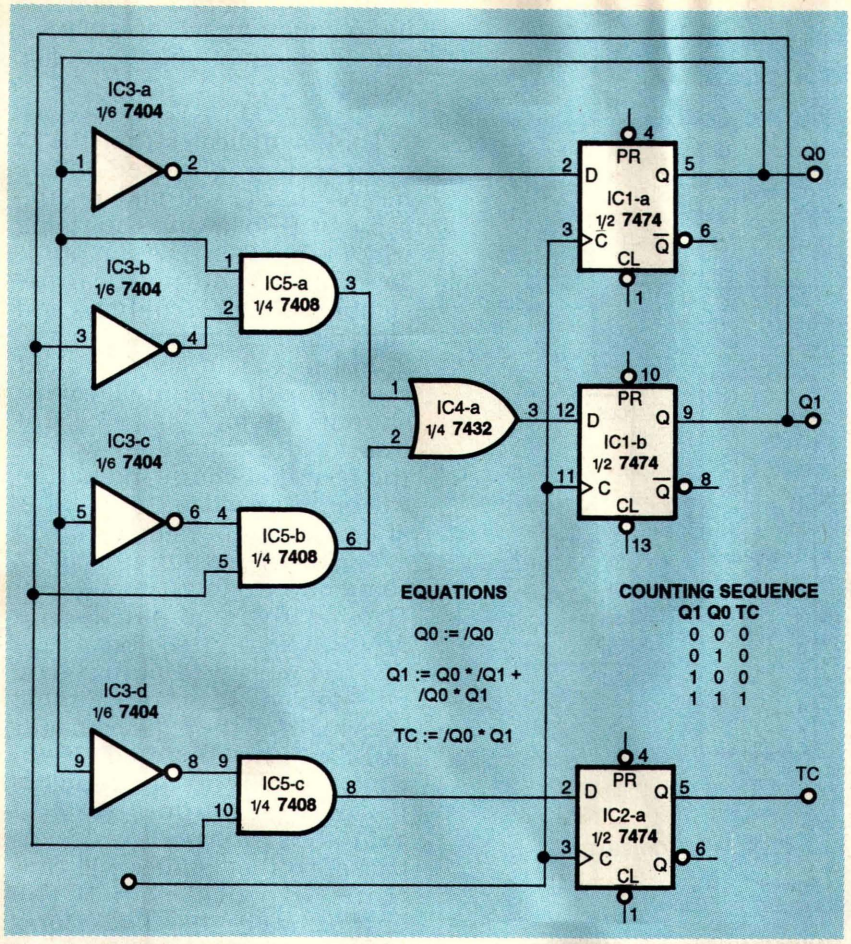


FIG. 3—TWO OR MORE OUTPUTS can be combined to form counters and shift registers; here is a 2-bit counter with a terminal count.

ground and pin 20 is V_{CC}. Pins 12–19 are each connected to Output Logic Macro Cells (OLMC). The OLMC allows these pins to act as inputs, combinatorial outputs, registered outputs, and input/output pins. Pins 2–9 are general-purpose input pins. If any of the OLMC are configured as registered outputs, then pin 1 is a CLOCK input and pin 11 is the OUTPUT ENABLE for the registered outputs. If none of the OLMC are registered, then pins 1 and 11 are general-purpose inputs. Internal to the chip is an array of AND/OR gates that's configured with each OLMC when the chip is programmed. The 20V8 has a similar design; the main difference between it and the 16V8 is that the 20V8 has four additional input pins.

Design tools

In addition to your PC, you will need only three tools to do design work with PLDs: a text editor, a logic compiler, and a device programmer. The construction of a suitable PC-based GAL programmer is covered elsewhere in this issue. A logic compiler is a program that translates a high-level design file in which the relationship between inputs and outputs is expressed in the form of equations to a low-level device-specific file for the programmer. The low-level file used by the programmer is called a JEDEC file, and is sometimes referred to as a "fuse map." (Earlier PLDs were programmed by literally blowing fuses inside the device, leaving only the desired connections. Of course they could not be reprogrammed; you simply threw away your mistakes.)

A logic compiler called Opal Jr. is available free from National Semiconductor. It's a no-frills version of its Opal logic compiler. It supports the 16V8 and 20V8 as well as other PLDs that National produces. The high-level design file for Opal Jr. is called an equation file and uses the extension .EQN. The output JEDEC file uses the extension .JED. Since Opal Jr. is available to everyone, it is used in the examples presented here. The concepts, however, are universal, and not specific to Opal Jr. The equation file is a standard ASCII text file and can be produced using any text editor.

Designing with equations

If you normally design with standard TTL devices, shifting to a design process using GALs might take a slight adjustment. However, the underlying concepts are the same. In the equations, a plus sign (+) is used to represent the OR function, a multiplication sign (×) to represent the AND function, and a bar

```
; CLOCK.EQN
; Low cost LOGIC ANALYZER clock selection GAL
;
CHIP clock 16V8

clk nc ext self s2 s1 s0 dir wr gnd
/oe sysclk1 wrdat sysclk0 q4 q3 q2 q1 q0 vcc

EQUATIONS

q0 :=   /q0

q1 :=   q0 * /q1 +
        /q0 * q1

q2 :=   q0 * q1 * /q2 +
        q2 * /q0 +
        q2 * /q1

q3 :=   q0 * q1 * q2 * /q3 +
        q3 * /q0 +
        q3 * /q1 +
        q3 * /q2

q4 :=   q0 * q1 * q2 * q3 * /q4 +
        q4 * /q0 +
        q4 * /q1 +
        q4 * /q2 +
        q4 * /q3

sysclk0 = /s0 * /s1 * /s2 * self +
          s0 * /s1 * /s2 * ext +
          s0 * s1 * /s2 * q4 +
          /s0 * /s1 * s2 * q3 +
          s0 * /s1 * s2 * q2 +
          /s0 * s1 * s2 * q1 +
          s0 * s1 * s2 * q0

sysclk1 = /s0 * /s1 * /s2 * self +
          s0 * /s1 * /s2 * ext +
          s0 * s1 * /s2 * q4 +
          /s0 * /s1 * s2 * q3 +
          s0 * /s1 * s2 * q2 +
          /s0 * s1 * s2 * q1 +
          s0 * s1 * s2 * q0

wrdat =  wr +
         dir
```

FIG. 4—EQUATION FILE CLOCK.EQN. The lines that start with a ";" are comment lines; they are ignored by the compiler but are used for documentation.

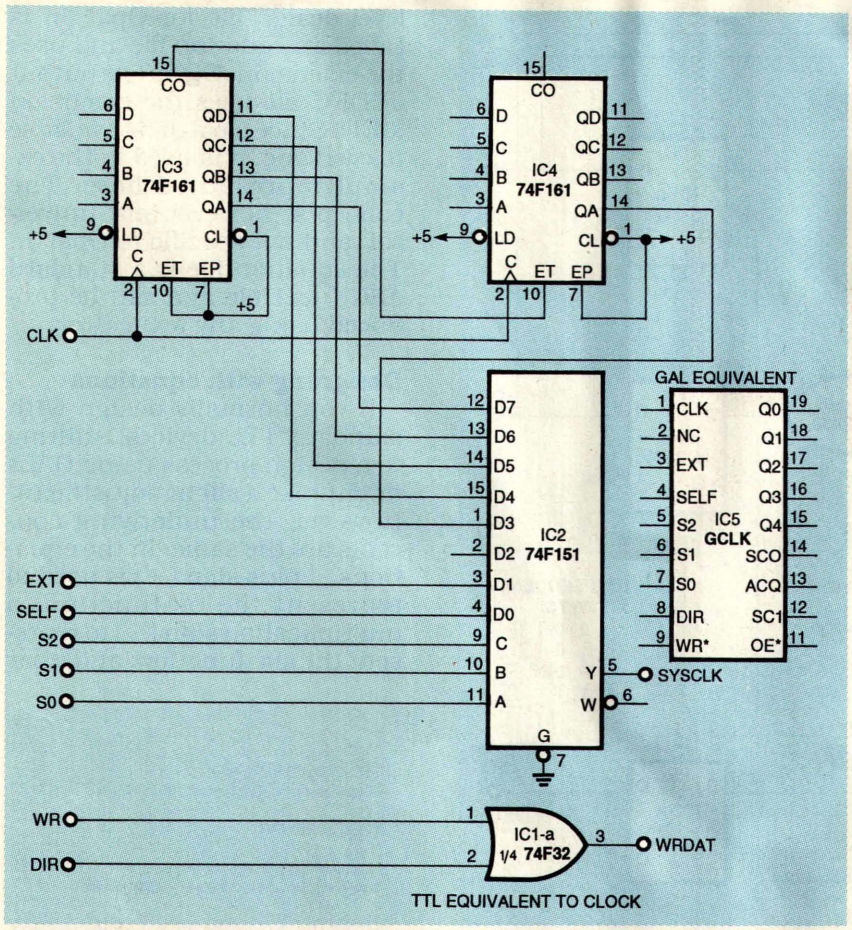


FIG. 5—EQUIVALENT CIRCUIT TO THE GAL. Notice the savings in device count.

over a character is for inversion (NOT). Figure 2-*a* shows the equation and symbol for an AND gate. Each group of signals AND ed together is referred to as a product term. Figure 2-*b* shows the equation and symbol for a 2-input OR gate. In Fig. 2-*c*, a more complicated logic array is represented. The equations are written in a sum of products format. It is a useful convention to list each product term on a separate line. The inversion can also occur on the output as shown is in Fig. 2-*d*. In the 16V8 and 20V8, up to eight outputs can be defined in this way (each of the eight OLMC). The inputs for the equations can come from any of the input or output pins, either normal or inverted. A maximum of seven or eight product terms is allowed for each OLMC, depending on the exact configuration of the OLMC.

So far, all the examples have involved combinatorial logic. GALs can also handle sequential logic such as is performed by shift registers and counters. To do this, the OLMC is configured as a register (a D-type flip-flop). If any of the OLMC are configured as registered, then pin 1 is the clock input to the register.

For example, an "=" sign shows a combinatorial output in an equation, a ":=" shows a registered equation output. For example:

$$Q := D$$

The := indicates that the Q output is registered. This means that Q will take on the value of D following the rising edge of the clock pulse on pin 1. Two or more outputs can be combined to form counters and shift registers, as shown in Fig. 3. In this case it shows a 2-bit counter with a terminal count. Outputs Q0 and Q1 will count from 0 to 3 continuously, and the terminal count indication will be active when the count is at its maximum value of 3.

The registered outputs have a common OUTPUT ENABLE at pin 11 on a 16V8 and pin 13 on a 20V8. When OUTPUT ENABLE is low, the registered outputs are all enabled. If output enable goes high, all the registered outputs will be disabled. Even when the outputs are disabled, the register outputs are still available internally as feedbacks, so the counter will continue to work even if the outputs were disabled. Combinatorial outputs can each have an output enable defined. This is limited to a single product term. For example:

$$X.OE = B \times C$$

That would indicate that output X should be enabled when B and C are high.

Design example

To illustrate the use of GALs in a practical design, the main board from a high-speed, low-cost 16-channel logic analyzer will serve as an example. The logic analyzer main board has a total of 17 ICs; of those, 2 are static RAMs, 4 are octal latches, 4 are octal buffers, and the remaining 7 are programmed GAL16V8s. All standard logic was performed by the 7 GALs. They replace about 20 high-speed TTL ICs and make the logic analyzer buildable.

Central to the logic analyzer is the clock-selection GAL, which allows the analyzer clock to be selected from five different internal clocks, an external clock, or a software-controlled clock. The Opal Jr. equation file,

RESOURCES

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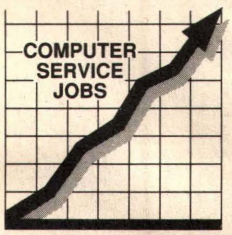

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```
EQN2JED - Boolean Equations to JEDEC file assembler (Version V003)
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Document file for clock.eqn
Device: 16V8

$LABELS 20 clk nc ext self s2 s1 s0 dir wr gnd /oe sysclk1 wrdat sysclk0 q4
 q3 q2 q1 q0 vcc


Pin   Label               Type
---   -----               ----
1     clk                 clock pin
2     nc                  unused
3     ext                 com input
4     self                com input
5     s2                  com input
6     s1                  com input
7     s0                  com input
8     dir                 com input
9     wr                  com input
10    gnd                 ground pin
11    oe                  enable pin
12    sysclk1             pos,trst,com output
13    wrdat               pos,trst,com output
14    sysclk0             pos,trst,com output
15    q4                  pos,reg feedback
16    q3                  pos,reg feedback
17    q2                  pos,reg feedback
18    q1                  pos,reg feedback
19    q0                  pos,reg feedback
20    vcc                 power pin



EQN2JED - Boolean Equations to JEDEC file assembler (Version V003)
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Device Utilization:

No of dedicated inputs used              :  7/8   (87.5%)
No of feedbacks used as dedicated outputs :  3/8   (37.5%)
No of feedbacks used                     :  5/8   (62.5%)

                ----------------------------------------
                Pin   Label                 Terms Usage
                ----------------------------------------
                19    q0                     1/8   (12.5%)
                18    q1                     2/8   (25.0%)
                17    q2                     3/8   (37.5%)
                16    q3                     4/8   (50.0%)
                15    q4                     5/8   (62.5%)
                14    sysclk0                8/8   (100.0%)
                13    wrdat                  3/8   (37.5%)
                12    sysclk1                8/8   (100.0%)
                ----------------------------------------
                Total                       34/64  (53.1%)
                ----------------------------------------



EQN2JED - Boolean Equations to JEDEC file assembler (Version V003)
Copyright (R) National Semiconductor Corporation 1990,1991

                    Chip diagram (DIP)

                      .------\_/------.
                clk   |  1        20  |  vcc
                 nc   |  2        19  |  q0
                ext   |  3        18  |  q1
               self   |  4        17  |  q2
                 s2   |  5        16  |  q3
                 s1   |  6        15  |  q4
                 s0   |  7        14  |  sysclk0
                dir   |  8        13  |  wrdat
                 wr   |  9        12  |  sysclk1
                gnd   | 10        11  |  /oe
                      '----------------'
```

FIG. 6—CLOCK.LOG FILE. The log file contains a lot of interesting information about the programmed device: the use of each device pin, the product term usage, and the device pinout.

```
GAL16V8
EQN2JED - Boolean Equations to JEDEC file assembler (Version V003)
Copyright (R) National Semiconductor Corporation 1990,1991
Assembled from "clock.eqn". Date: 6-9-93
*
QF2194*QP20*F0*
L0000
11101111111111111111111111111111*
L0256
11011110111111111111111111111111
11101101111111111111111111111111*
L0512
11011101111011111111111111111111
11101111110111111111111111111111
11111110110111111111111111111111*
L0768
11011101110111101111111111111111
11101111111111011111111111111111
11111110111111011111111111111111
11111111111101101111111111111111*
L1024
11011101110111011110111111111111
11101111111111111101111111111111
11111110111111111101111111111111
11111111111011111101111111111111
11111111111111101101111111111111*
L1280
11111111111111111111111111111111
11111111011110111011101111111111
11110111111110111011011111111111
11111111111110110101011111111111
11111111111101011011101111111111
11111111101011110111011111111111
11111101111011101110111011111111
11011111111101110111011111111111*
L1536
11111111111111111111111111111111
11111111111111111111111111110111
11111111111111111111111101111111*
L1792
11111111111111111111111111111111
11111110111101110111011111111111
11110111111110111011011111111111
11111111111110110101011111111111
11111111111101011011101111111111
11111111101011110111011111111111
11111101111011101110111011111111
11011111111101110111011111111111*
L2048
11111111*
L2056
00000000000000000000000000000000000000000000000000000000000000000000000000000000*
L2120
00000111*
L2128
10000000110000001110000011110000111110001111111111100000111111111*
L2192
01*
C823E*
```

FIG. 7—CLOCK.JED FILE. This is used by the programmer to configure the chip. It will make sense only if you have carefully studied the GAL16V8 data book.

CLOCK.EQN, is shown in Fig. 4. The lines that start with a ";" are comment lines; they are ignored by the compiler and are used for documentation. The equation file must contain two sections: the declaration section and the equation section. The declaration section should appear first, and is indicated by the keyword CHIP. The line "CHIP clock 16V8" begins the declaration block, it gives the chip a name (clock), and selects the device type (16V8). The next part of the declaration block is optional, but will be needed in most cases. In this section symbolic names are assigned to each pin on the chip, as follows: clk nc ext self s2 s1 s0 dir wr gnd /oe sysclk1 wrdat sysclk0 q4 q3 q2 q1 q0 vcc

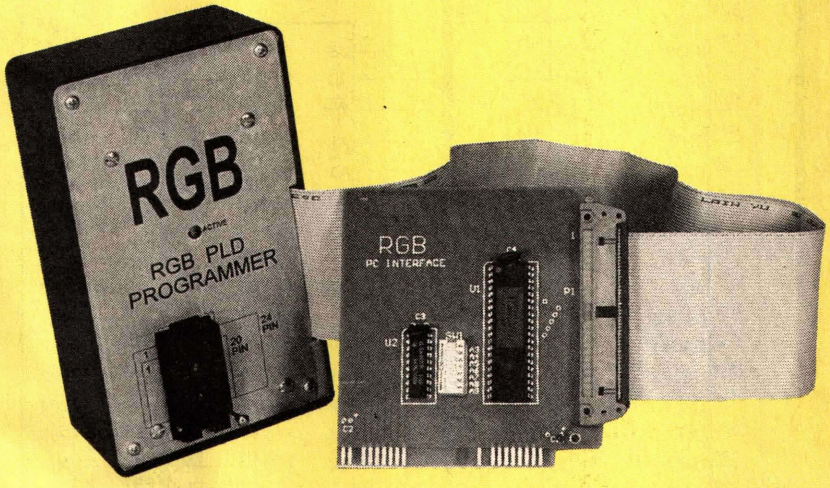
The symbolic names start with pin 1 and are assigned in order through pin 20. In this case, pin 1 is assigned the name CLK, pin 9 WR, pin 12 SYSCLK1, and pin 19 the Q0. If you later need to change the pin assignments, simply rearrange the names given here.

The equation section of the file is indicated by a line with the word "EQUATIONS." Outputs Q0, Q1, Q2, Q3 and Q4 form a 5-bit counter (a straight forward expansion of the 2-bit

Continued on page 84

ROBERT G. BROWN

BUILD THIS PLD PROGRAMMER



Build a programmable logic device (PLD) programmer at a very affordable price.

THERE ARE MANY GOOD REASONS why you would want to include programmable logic devices (PLDs) in your designs. Programmable logic devices save PC board space, reduce cost, and add design flexibility when compared to standard TTL logic devices. The main reason for avoiding design with programmable logic until now has been the high cost of PLD (programmable logic device) programmers. But now you can build a programmer from a kit for only $150.00—far below the price of commercial programmers.

This programmer can program the GAL16V8A, GAL16V8B, GAL20V8A, and GAL20V8B PLDs from Lattice Semiconductor Corp., SGS-Thomson Microelectronics, and National Semiconductor. The ability to program only 16V8 and 20V8 devices might seem to be restrictive, but it really is not. The GAL is a second-generation PLD, and it is more flexible than the first generation PAL. Table 1 shows which PALs can be directly replaced with the 16V8 and 20V8 devices.

In addition to being able to replace those PAL devices, GALs can perform logic functions that cannot be performed by any of the standard PALs. GALs can also be reprogrammed in seconds, while PALs are one-time only (OTO) programmable, so GALs are ideal for use by the experimenter.

TABLE 1—GAL COMPATIBILITY

16V8	20V8
16R6	20R6
16R4	20R4
16RP8	20RP8
16RP6	20RP6
16RP4	20RP4
16L8	20L8
16H8	20H8
16P8	20P8
10L8	14L8
16L6	16L6
14L4	18L4
16L2	20L2
10H8	14H8
16H6	16H6
14H4	18H4
16H2	20H2
10P8	14P8
12P6	16P6
14P4	18P4
16P2	20P2

Theory of operation

The programmer is composed of two separate modules: an interface board that plugs into a slot in your personal computer and a main programmer module that is external to the PC. The modules are connected by a ribbon cable terminated by a 50-pin connector.

The interface board is a standard two-device parallel interface (see Fig. 1). The 8255 programmable peripheral interface (IC6) has three 8-bit parallel ports that can be organized by software as a flexible interface. In the normal operation of the programmer, Ports A and B are configured as outputs, and Port C is configured with bits 0–3 as outputs and bits 4–7 as inputs.

The second chip is a 74LS682 8-bit totem-pole comparator (IC7) that decodes addresses for the 8255. The 74LS682 pulls pin 19 low when its P inputs equal it's Q inputs. The eight Q inputs have internal 10K pull-up resistors so they remain high unless forced low. The 8255 address is selected by DIP switch S1; each switch pulls the corresponding Q input low. When the address on the PC bus (the P inputs) matches the address selected by S1 (the Q inputs), a CHIP SELECT is generated for the 8255. If it is an I/O cycle, then either IOR or IOW will also be asserted, and data will be read from or written to the 8255 register selected by A0 and A1. The 8255 base address is specified for the software in the configuration file.

Fifty-pin connector P1 is the

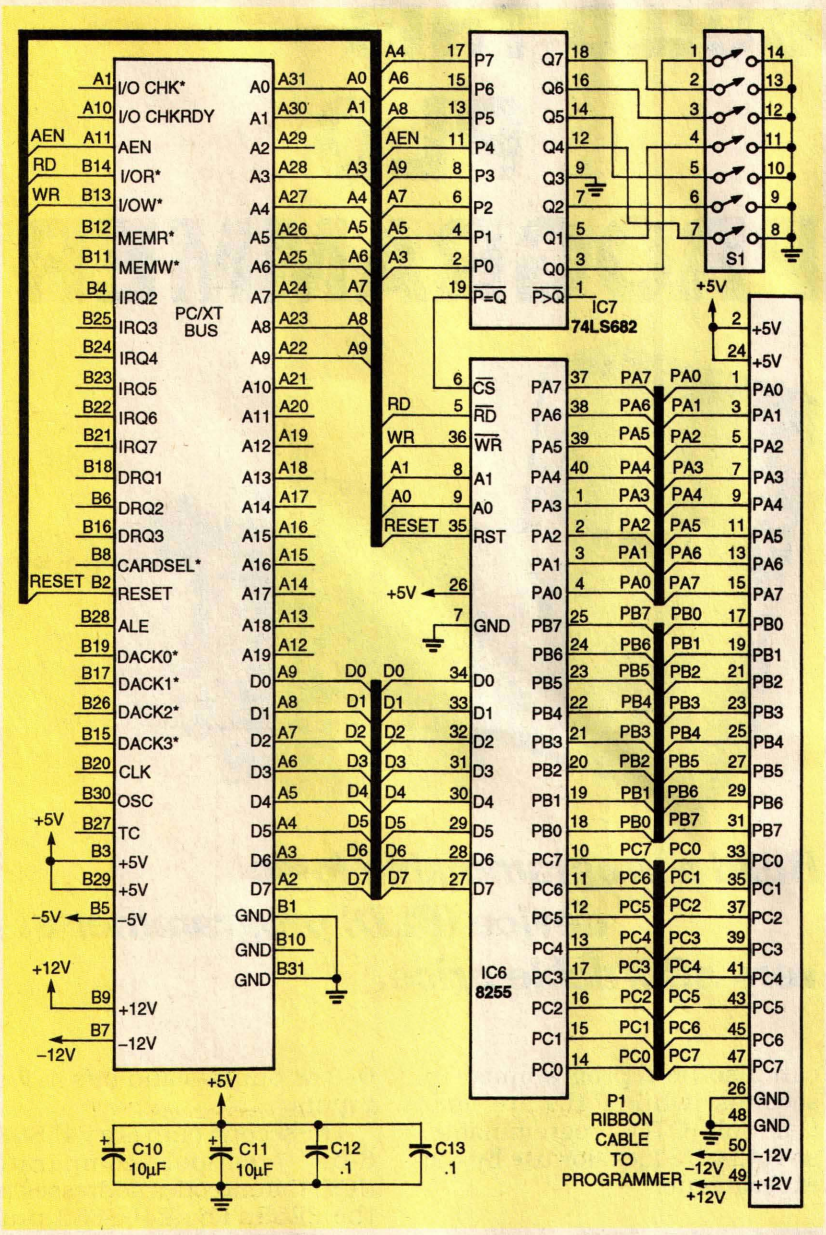


FIG. 1—THE INTERFACE BOARD is a standard two-device parallel interface. The 8255 programmable peripheral interface has three 8-bit parallel ports that can be configured by software.

bridge to the main programmer board. Each of the three 8-bit ports from the 8255 are connected to P1. Of the remaining 26 lines, 12 are connected to PC ground, 12 to the PC +5-volt supply, 1 to the PC +12 volt supply, and 1 to the −12-volt supply.

The main programmer board is shown in Fig. 2. Its single 24-pin zero insertion force (ZIF) test socket, SO1, accepts both the 24-pin 20V8 and the 20-pin 16V8. The 16V8 is inserted in the ZIF socket so that pins 1, 2, 23, and 24 of the socket are not used. Note that the programmer circuitry uses one 16V8 GAL (IC3) in its design. It is set up to perform specific functions for the programmer. The equation file for IC3 is shown in Listing 1.

During programming, the GAL pins take on special functions. The programming pinout of the both the 16V8 (in the 24-pin ZIF socket) and 20V8 are shown in Fig. 3. To prepare the GALs for their programming mode, a voltage above the normal operational range of the device must be applied to pin 2. The programming voltage must be switchable between 0.0, 12.0, 14.5, and 16.5 volts. The remaining signals are standard TTL (0 to 5-volt) levels that are controlled from the interface.

The programming voltage is generated by IC2 in combination with C1, C2, D1, and D2 to form a voltage-doubler circuit that takes 12 volts from the interface and converts it to about 22.6 volts (12 × 2 minus the two diode drops). The 22.6-volt output from IC2 is fed into adjustable voltage regulator IC1, whose output voltage is controlled by the resistance between pin 1 and ground. Transistors Q1 and Q2 permit that resistance to be controlled, thereby selecting different voltages at the regulator output. When signals VSEL0 and VSEL1 are low, Q1 and Q2 are shut off, and the resistance to ground is simply the series resistance of R9 and R8. The output of IC1 is set by R8 to 16.5 volts.

When VSEL0 is high and VSEL1

LISTING 1—IC3 EQUATIONS

```
CHIP pld1 16V8

nc ps14 ps15 pa5 pa4 pa3 pa2 pa1 pa0 gnd
nc vsel0 vsel1 led vcc24 vcc22 data do14 do15 vcc

EQUATIONS

vsel0 = pa0

vsel1 = pa1

vcc22 = pa2

vcc24 = pa3

do14 = pa4

do15 = pa5

data = pa4 * ps14 +
       /pa4 * ps15

led = pa2 * pa3
```

INTERFACE BOARD PARTS LIST

IC6—8255A-5 programmable peripheral interface (Intel or equivalent)
IC7—74LS682 8-bit comparator (Motorola or equivalent)
S1—14-pin DIP switch
P1—50-pin right-angle IDC male header
C1, C2—10 µF, 6 volts, tantalum electrolytic
C3, C4—0.1 µF, ceramic
Interface cable—50-conductor ribbon cable terminated with IDC sockets at both ends
PC board, solder

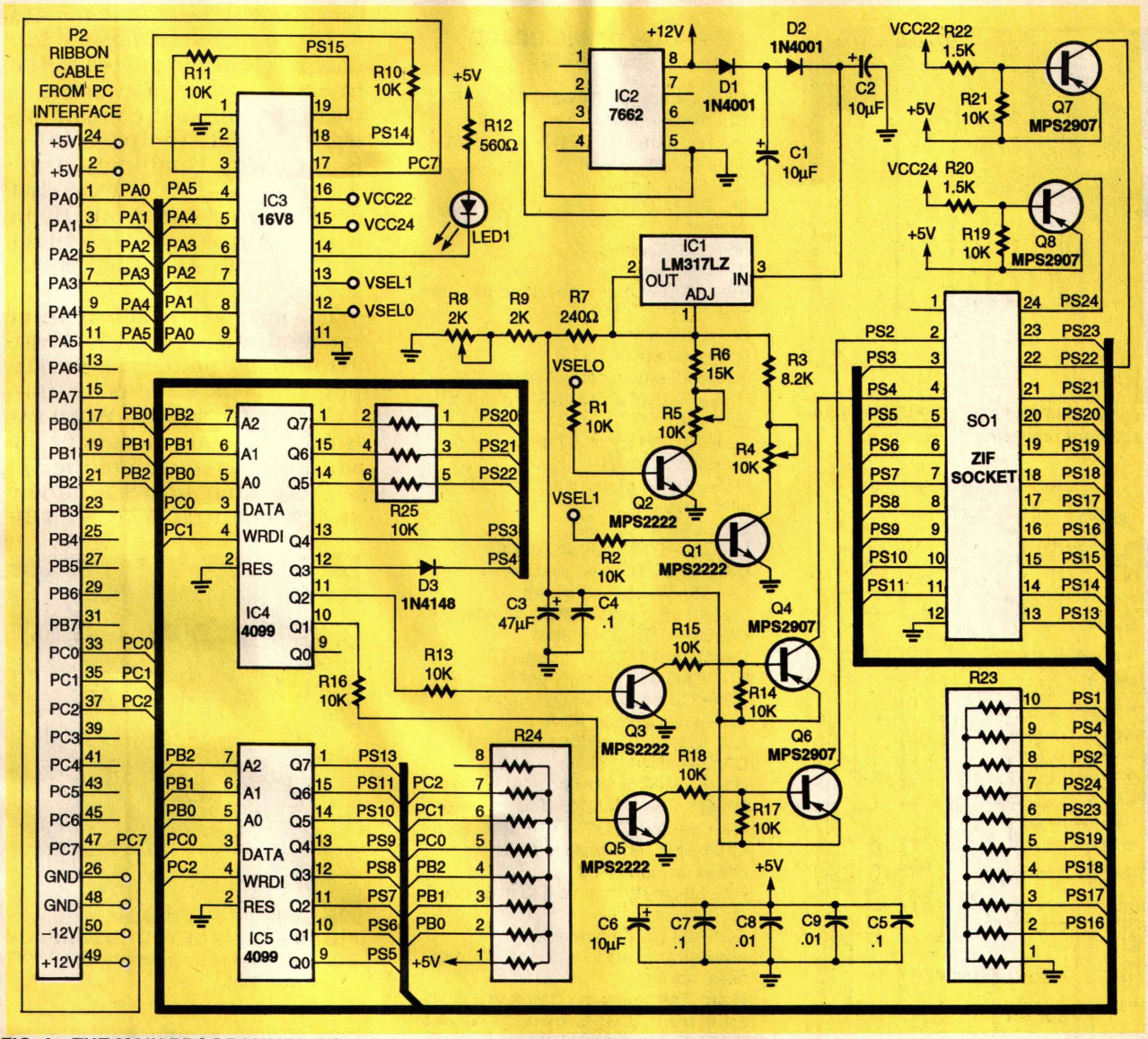


FIG. 2—THE MAIN PROGRAMMER BOARD has a single 24-pin ZIF socket to accommodate both the 24-pin 20V8 and the 20-pin 16V8 PLDs.

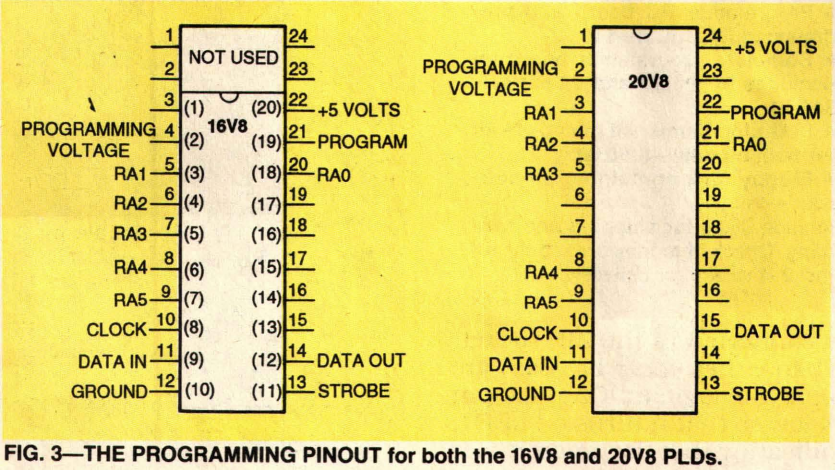


FIG. 3—THE PROGRAMMING PINOUT for both the 16V8 and 20V8 PLDs.

is low, Q2 is turned on, and the resistance to ground is reduced by placing R5 and R6 in parallel with R8 and R9; R5 is adjusted to give an output of 14.5 volts. When both VSELO and VSEL1 are high, Q2 and Q1 are turned on. That places R3 and R4 in parallel with R5, R6, R8, and R9, which again decreases the resistance, again lowering the output voltage. The output voltage is adjusted by R4 to 12.0 volts. In this way, the programming voltage can be selected from two control signals originating at the interface.

Programming voltage must be applied to either pin 2 or pin 4 of the ZIF socket. Transistor pairs Q3 and Q4 form a switch that controls the application of the programming voltage to pin 2 of the ZIF socket. When the signal to the base of Q3 is high, Q3 turns on, pulling the base of Q4 low. That response turns Q4 on and applies the programming voltage to pin 2 of the ZIF

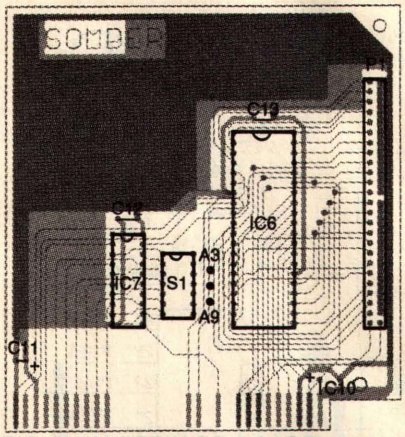


FIG. 4—INTERFACE BOARD parts-placement diagram.

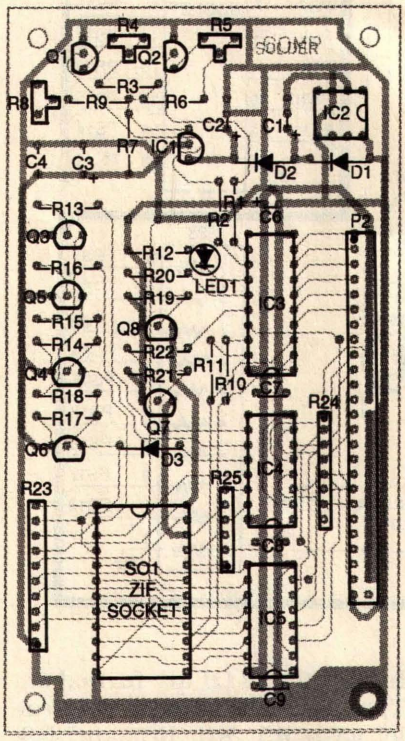


FIG. 5—PROGRAMMER BOARD parts-placement diagram. Make sure the LED lens is positioned high enough off the board to project through the case.

socket. When the signal into the base of Q3 is low, Q3 turns off. That turns Q4 off and removes the programming voltage from pin 2. In the same way, Q5 and Q6 control the programming voltage for pin 4 of the ZIF test socket.

The +5-volt power to the chip being programmed in the ZIF socket is switched by signals VCC22 and VCC24 from IC3. When either VCC22 or VCC24 are low, the respective transistor (Q7 or Q8) is turned on and the 5-volt power from the interface is connected to the ZIF socket. When either VCC22 or VCC24 are high, the logic in IC3 pulls pin 14 low so that it turns on LED1, indicating that the programmer is active.

As mentioned before, the equation file for IC3 is shown in Listing 1. Outputs VSEL0, VSEL1, VCC22, VCC24, DO14 and DO15 of IC3 are buffered versions of signals received directly from the interface cable. Buffering is necessary to ensure signal integrity. The LED output (pin 14) is the OR'ed combination of VCC22 (PA2) and VCC24 (PA3). That combination turns LED1 on when power is applied to either pin 22 or pin 24 of the ZIF test socket.

The logic for the data output is slightly more complex. When PA4 is high, the state of the output data is the same as PS14 (pin 14 of the ZIF socket). When PA4 is low, the state of data is the same as PS15 (pin 15 of the ZIF socket). That forms a simple switch for selecting the data in-

PROGRAMMER BOARD PARTS LIST

All resistors are ¼-watt, 5%, unless otherwise noted.
R1, R2, R10, R11, R13–R19, R21—10,000 ohms, ⅛-watt
R3—8200 ohms
R4, R5—10,000 ohms, vertical-mount trimmer
R6—15,000 ohms
R7—240 ohms
R8—2000 ohms, vertical-mount trimmer
R9—2000 ohms
R12—560 ohms
R20, R22—1500 ohms, ⅛-watt
R23—10,000 ohms ×9, 10-pin SIP, pin-1 common
R24—10,000 ohms ×7, 8-pin SIP, pin-1 common
R25—10,000 ohms ×3, 6-pin SIP, isolated resistors
Capacitors
C1, C2—10 µF, 25 volts, electrolytic
C3—47 µF, 25 volts, electrolytic
C4, C5, C7—0.1 µF, ceramic
C6—10 µF, 6 volts, tantalum electrolytic
C8, C9—0.01 µF, ceramic
Capacitors
IC1—LM317LZ voltage regulator
IC2—ICL7662 voltage converter
IC3—programmed 16V8
IC4, IC5—4099 addressable 8-bit latch
D1, D2—1N4001 diode
D3—1N4148 or 1N914 diode
Q1–Q3, Q5—PN2222 NPN transistor
Q4, Q6–Q8—PN2907 PNP transistor
LED1—red light-emitting diode
Other components
P2—50-pin right-angle IDC male header
SO1—24 pin ZIF socket
Miscellaneous: PC board, project case, solder
Note: The following items are available from R.G. Brown, 30 Wicks Road, E. Northport, NY 11731:
- **Interface PC board only—$40.00**
- **Complete interface kit (includes PCB and all parts)—$75.00**
- **Programmer PC board and programmed GAL (IC3)—$40.00**
- **Complete programmer board kit (includes PC board and all parts)—$85.00**
- **PLD programmer kit (complete kit for both boards)—$150.00**
- **Floppy disk containing all software—$10.00**

Include $5.00 for shipping and handling. Check or money order only. Allow 2–4 weeks for delivery.

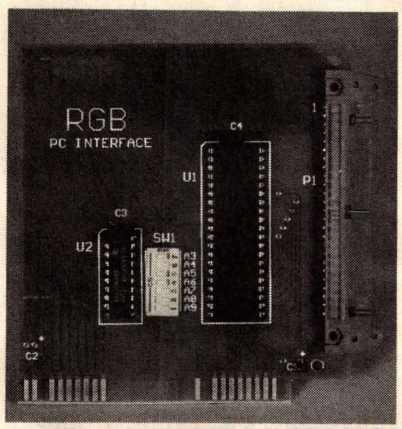


FIG. 6—COMPLETED INTERFACE BOARD. This fits in an empty IBM PC/XT expansion slot.

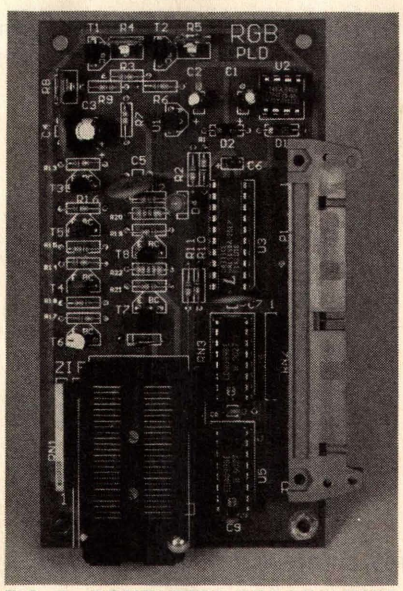
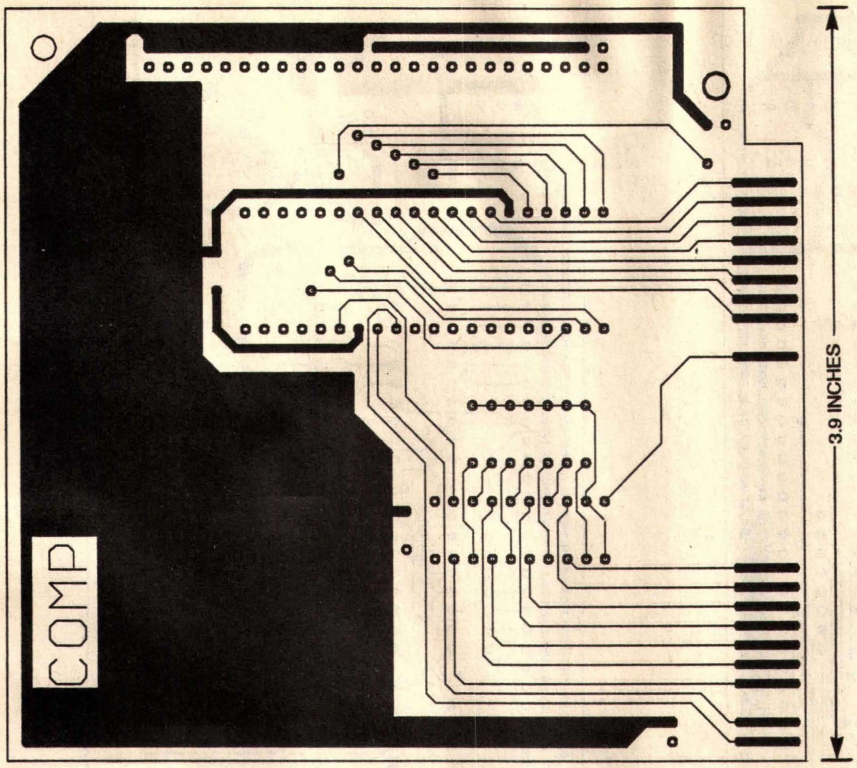
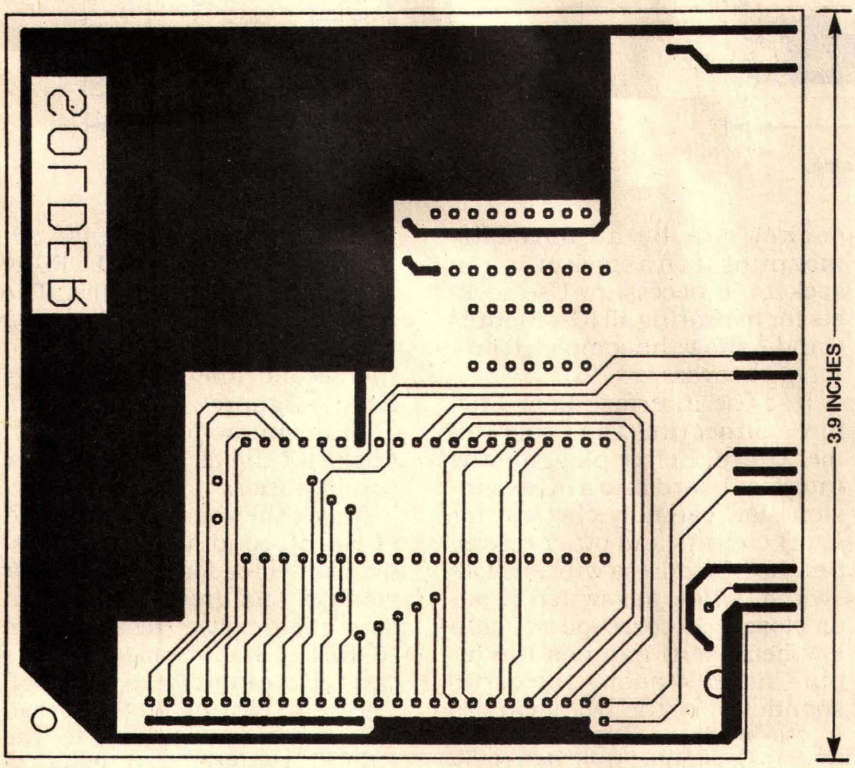


FIG. 7—COMPLETED PROGRAMMER BOARD. The ZIF socket height above the circuit board can be adjusted by mounting it on a stack of 24-pin sockets.



INTERFACE BOARD, component side.



INTERFACE BOARD, solder side.

put source. While this logic is simple, its replacement with standard TTL devices would require several 14 or 16 pin packages. This logic circuit fits in a single 20-pin GAL16V8 package, saving PC board space and making PC board layout much simpler.

Data is read in from the chip being programmed through either PS14 (16V8) or PS15 (20V8). The GAL output is open-drain during programming so it is pulled up through either R10 or R11. The input signal appears at the interface on PC7.

The remaining pins are driven by IC4 and IC5. These are 8-bit addressable latches. The bit address is placed on A0, A1, and A2 (pins 5, 6, and 7). The data to be latched is put on pin 3. When pin 4 is high, the data from pin 3 is placed on the addressed output pin (if A0 = 0, A1 = 0, A2 = 0, and DATA = 1, then Q0 = 1). When pin 4 is returned to low, the data is latched.

Building the programmer

Before building the programmer, you should obtain a copy of the software (RGBPLD.ZIP) from the *Electronics Now BBS* (516-293-2283, V.32, V.42bis) or from the source given in the Parts List. The software will be needed for testing the completed programmer.

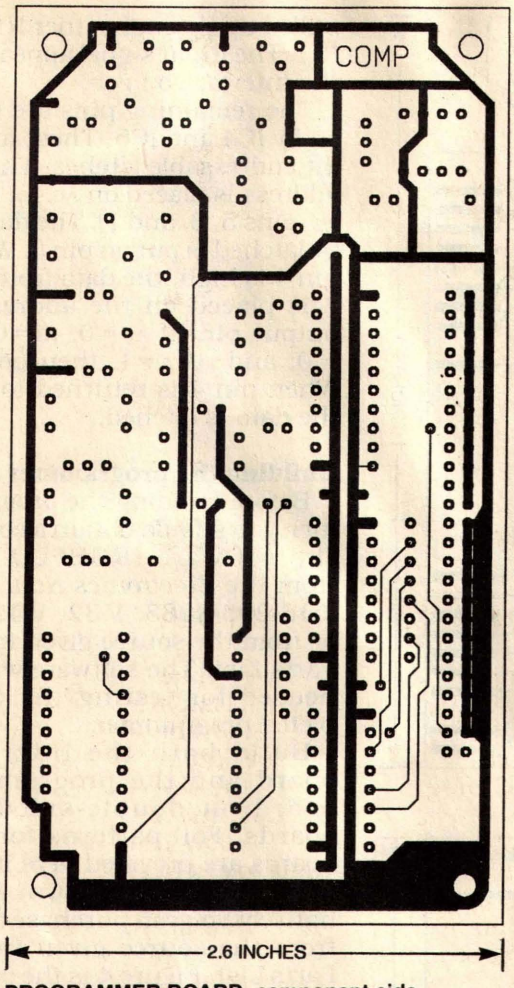
Build both the interface board and the programmer board on double-sided PC boards. Foil patterns for the boards are provided here if you want to make your own. Alternatively, you can purchase them from the source given in the Parts List. Figure 4 is the parts-placement diagram for the interface board. If you elect to point-to-point wire the circuit on a PC/XT prototype board,

```
RGB PLD PROGRAMMER SETUP and TEST Rev 1.0
(C) COPYRIGHT 1992 Robert G. Brown
All Rights Reserved

F1  - programming voltage setup
F2  - VCC pin 22 check
F3  - VCC pin 24 check
F4  - data input test
F5  - pin drivers check
F10 - exit
```

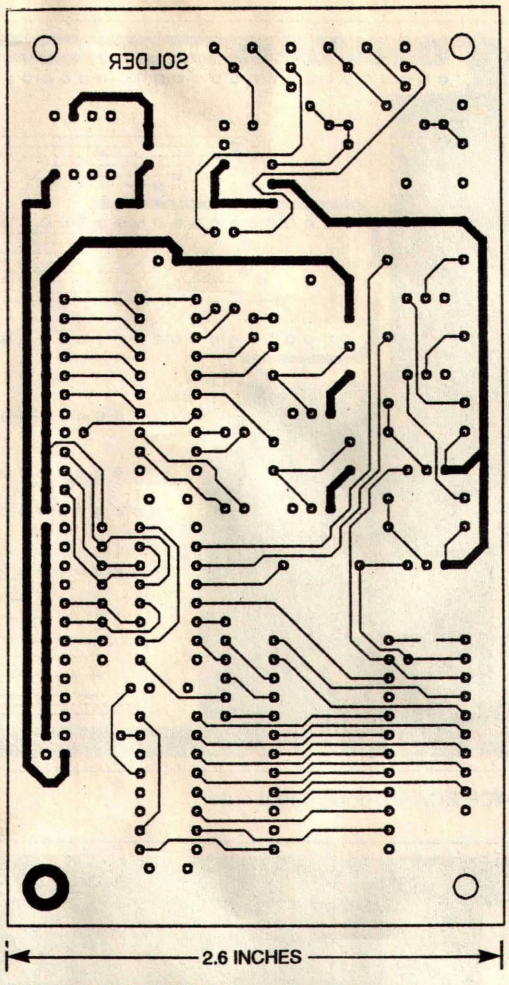
FIG. 8—SETUP MENU. Run through each of these tests during initial setup.

```
RGB PLD PROGRAMMER Rev 1.0
(C) COPYRIGHT 1992 Robert G. Brown
All Rights Reserved

PRIMARY BUFFER UES:
VERFIFY BUFFER UES:

F1  - device 16V8A
F2  - read jedec file
F3  - program
F4  - verify
F5  - secure
F6  - load device
F7  - write jedec file

F10 - exit
```

FIG. 9—MAIN MENU. Before placing a chip in the ZIF socket, select the correct device type with F1; incorrect selection could destroy the PLD.



PROGRAMMER BOARD, component side.



PROGRAMMER BOARD, solder side.

make the +5 volt and ground connections from the PC bus to P1 with 14 to 16 AWG wire.

Figure 5 is the parts-placement diagram for the programmer board. If you want to mount the board in a case, be sure the LED is positioned high enough above the board so that its lens will project through a hole in the case. The height of the ZIF test socket can be adjusted by mounting it on a stack of 24-pin sockets, if necessary. Use sockets for mounting all ICs. Figures 6 and 7 show the completed prototype boards.

Test the interface board before connecting the programmer board. Before plugging the interface board into a PC expansion slot, carefully check it for short circuits and other errors. Set the I/O address with the DIP switch. When the switch is on, or closed, it corresponds to a low because it grounds the input. Figure 4 shows the correspondence of the DIP switches to the address lines. Address 390H is usually free. It corresponds to A9 off, A8 off, A7 off, A6 on, A5 on, A4 off, and A3 on.

When the address is set, plug in the board and power up the PC; if the PC does not boot up properly, power down and look for mistakes or omissions. Edit the configuration file RGBPLD.CFG to match the address selected. RGBPLD.CFG is a two-line ASCII text file. The first line contains the base I/O address in hex (i.e., 390), and the second line should always have 1. Ignore any characters after the numeric value on each line. Edit the file to match your configuration.

Check the voltages at the end of the 50-conductor ribbon cable connector for proper power voltages and ground, and then start the interface test program RGBINT. The interface test lets you read and write to the 8255 registers. Writing an 80 (all values expressed in hex) to the CNTRL register will program ports A, B, and C as outputs. Check each bit of the three ports at the end of the cable. Different values can be written to the ports from the diagnostic program. If the interface fails to respond, be sure the configura-

Continued on page 84

RESOURCE LIST

Lattice Semiconductor Corporation
P.O. Box 2500
Portland, Oregon 97208
(503) 681-0118
(800) FAST GAL

National Semiconductor Corporation
2900 Semiconductor Drive
P.O. Box 58090
Santa Clara, CA 95052-8090
(800) 272-9959

SGS-Thomson Microelectronics
1000 East Bell Road
Phoenix, AZ 85022-2699
(602) 867-6340

LOW-COST COLORIMETER

Identify more than 1000 colors with this $39 circuit.

JOSEPH SCHNABLE, GEORGE ALESSANDRO, AND ROBERT ORR*

COMMERCIALLY AVAILABLE COLOR-formulation systems, colorimeters, and spectrophotometers are suitable for identifying the visible color of a surface. These instruments typically scan a surface with 400–700 nanometer (nm) visible light, compare the sample with color references, and determine the best color match based on a set of built-in standards. Most commercial instruments depend on expensive optics and cost $1000 or more. This article describes a $39 color-identifier circuit that can easily identify 1000 or more colors with 100% accuracy. For $39 it's impossible to build a very intelligent device. However, most of us own personal computers; why not use it as the brain? That's what we did here.

A hardware/software combination activates, in turn, one of several LEDs; each emits a portion of the visible spectrum. A phototransistor measures the light reflected by the surface being measured, and an 8-bit analog-to-digital converter (ADC) translates the phototransistor's output into a digital format that the computer can interpret. Seven LEDs (blue, aqua, green, yellow, orange, crimson, and red) provide a range of readings across the visible spectrum. Lack of spectral continuity among adjacent LED colors could skew results, so the circuit provides built-in compensation for this error.

Two simple BASIC programs control the circuit's operation. One allows you to define a set of standards by measuring known color samples and recording the values with an associated name. The other program measures unknown samples and provides the best match with the defined standards, as well as a relative error factor.

Circuit description

Figure 1 shows the complete circuit. Three ICs do the work. First is IC1, a 74HCT688 8-bit comparator that provides a low-going signal on pin 19 when the values on IC1's P and Q inputs are equal. That happens when there is no direct-memory access (DMA) occurring (i.e., AEN is low), when address line A9 is high, and when address lines A3–A8 are low. If you work out the math, you'll see that this occurs whenever any I/O port in the range 512–519 is accessed. If those port addresses are used on your system, you can easily change the values by connecting different Q inputs to ground and +5-volts DC. You will also need to change the value of ADR as defined in line 2 of both BASIC programs.

Every time pin 19 of IC1 goes low, IC3 latches the current contents of the 8-bit data bus. These latched values in turn drive the seven LEDs. (LED2 is a dual unit containing both red and yellow LEDs, so there are only six actual devices.) Pin 19 of IC1 also drives the $\overline{RD}$ input of IC2, an 8-bit ADC. That causes IC2 to sample the voltage appearing at its input pin 6.

That voltage depends primarily on the amount of light shining on Q1, a general-purpose phototransistor. The authors used a PN168PA-ND sold by Digi-Key Corp. The phototransistor must be mounted so that when a measurement is taken, it will only detect light from the LED array. The input voltage to the ADC also depends on the state of pin 19 of IC3. When that pin is low, resistor R3 is effectively in parallel with R2, thus changing the bias on the phototransistor, hence the voltage at pin 6 of the ADC. The ADC's clock frequency depends on the values of R1 and C1, which gives a frequency of about 400 kHz.

Note that an A/D conversion occurs whenever the system accesses I/O port 512–19. But other events happen as well, depending on whether an I/O read ($\overline{I/OR}$) or an I/O write ($\overline{I/OW}$) has occurred.

If CPU signal $\overline{I/OR}$ goes low, pin 3 of the ADC in turn goes low,

*Delaware Valley College Chemistry Department, Doylestown, PA

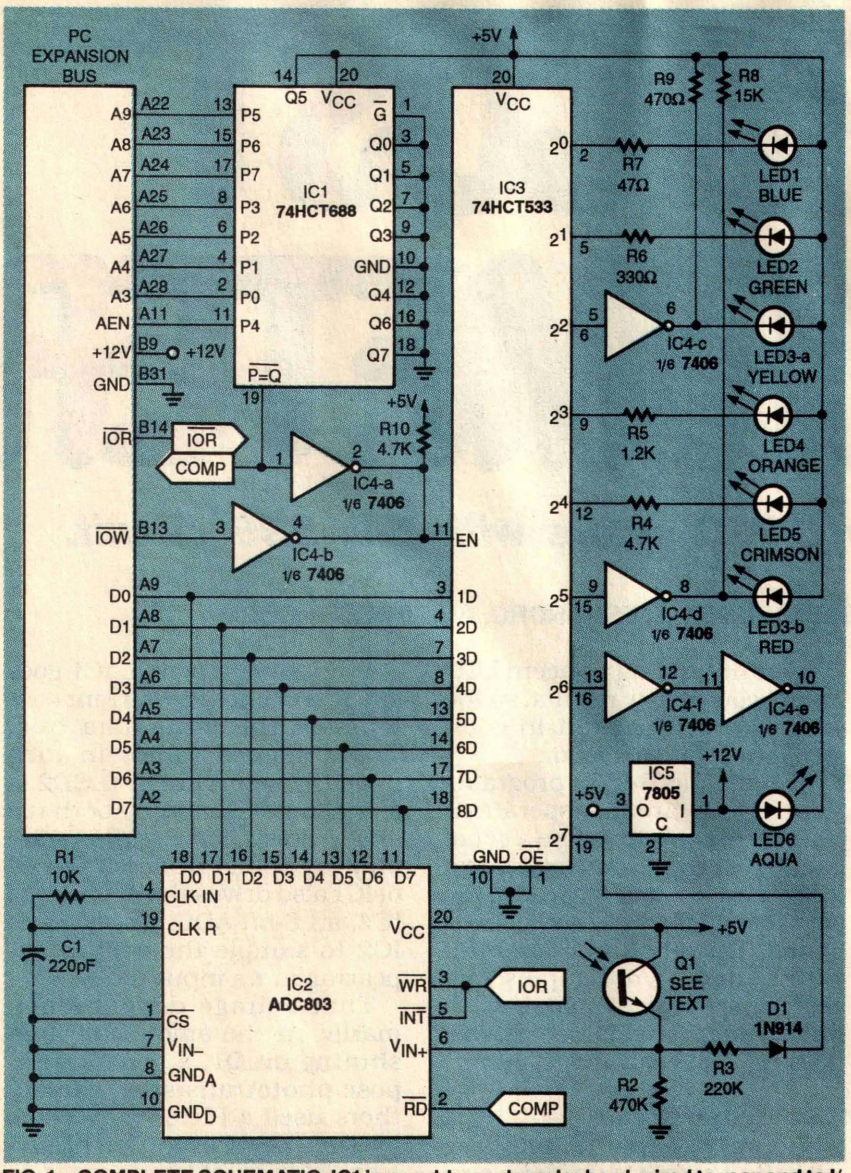


FIG. 1—COMPLETE SCHEMATIC. IC1 is an address decoder hard-wired to respond to I/O ports 512–519. IC2 is an A-to-D converter that measures the voltage across R2, which depends on the amount of light shining on Q1. IC3 is an 8-bit inverting latch that the software drives to successively light each LED during a scan.

forcing the ADC to present its most recently collected value to the data bus. On the other hand, if CPU signal $\overline{IOW}$ goes low, pin 11 of IC3 goes high, thereby latching the values on the data bus into IC3. Each register in IC3 provides a latched, inverted output capable of sinking 35 milliamperes.

LEDs

Table 1 summarizes important information about the LEDs. The activation code is the value that must be set into the assigned I/O port to activate or deactivate a given LED. Values can, of course, be summed to enable or disable several LEDs at once.

Note that LED6, the aqua emitter, requires direct connection to +12V. At $12.50, it was rather expensive when first introduced, but the price has dropped slightly. (The LED is available, as part 48-6E for $10.26 plus shipping from Parts 1, 1995 County Rd. B2, Roseville, MN 55113; 800-424-6204.)

Both LED3 and LED4 are dual units. The circuit includes both the yellow and red units in LED3, but it uses only the orange unit in LED4.

The values of R4–R9 were selected to provide an ADC response range from approximately 5 (for a black surface) to 200 (for a white surface) for each LED. That will provide a maximum response range for most colors. Higher ADC values might cause the phototransistor to saturate, thereby preventing the circuit from reliably distinguishing different colors.

Although there is some overlap between the two, there is a large spectral gap between the aqua (LED6, 482 nm) and green (LED2, 560 nm) LEDs. We solved the problem by energizing both LEDs simultaneously and decreasing ADC sensitivity. By keying a value of 194 (128 + 64 + 2), both LEDs are turned on and R3 is enabled via diode D1. This increases the number of colors that can be identified from a few hundred to more than 1000.

The authors used a separate 7805 voltage regulator, driven by the host computer's +12-volt supply, to power the other ICs in the circuit. This minimized inconsistent results obtained by running the circuit in different computers with slightly different +5-volt supplies. Thus calibration is generally much machine independent.

Software considerations

Listings 1 and 2 present the calibration and identification programs, respectively. (These files are available on the *Electronics Now BBS*, 516-293-2283, 9600 baud, as file 1KCOLOR.ZIP.) The calibration program uses two external files, CAL1 and CAL2, to store information. CAL1 stores standard values, and CAL2 stores corresponding names.

TABLE 1—LED COLORS AND CODES

LED	Wavelength	Color	Activation Value
LED1	470 nm	Blue	2^0=1
LED2	560 nm	Green	2^1=2
LED3-a	590 nm	Yellow	2^2=4
LED3-b	700 nm	Red	2^3=8
LED4	630 nm	Orange	2^4=16
LED5	665 nm	Crimson	2^5=32
LED6	482 nm	Aqua	2^6=64

LISTING 1—CALIBRATION PROGRAM

```
10 'CALIBRAT.BAS calibration program
20 CLS:KEY OFF:N=0:ADR=512:OPEN"R",1,"CAL1",16:OPEN"r",2,"cal2",24
30 FIELD 1,2AS B$,2AS G$,2AS Y$,2AS O$,2AS C$,2AS R$,2AS A$,2AS AG$
40 FIELD 2,24AS ID$
50 PRINT "reference number",N+1:OUT ADR,255:BEEP:INPUT "Enter Name of Standard
or 'E' To End";TEMPID$
60 IF TEMPID$="E" OR TEMPID$="e" THEN N=0: GOTO 200
70 IF TEMPID$="n" THEN INPUT"enter n to redo ",N:N=N-1:GOTO 50
80 N=N+1:FOR H=0 TO 7:K=0:IF H<7 THEN Z=2^H ELSE Z=194
90 OUT ADR,Z:FOR I=1 TO 500:NEXT I
100 FOR J=1 TO 50:K=K+INP(ADR):NEXT J
110 IF H=0 THEN LSET B$=MKI$(K)
120 IF H=1 THEN LSET G$=MKI$(K)
130 IF H=2 THEN LSET Y$=MKI$(K)
140 IF H=3 THEN LSET O$=MKI$(K)
150 IF H=4 THEN LSET C$=MKI$(K)
160 IF H=5 THEN LSET R$=MKI$(K)
170 IF H=6 THEN LSET A$=MKI$(K)
180 IF H=7 THEN LSET AG$=MKI$(K)
190 NEXT H:LSET ID$=TEMPID$:PUT 1,N:PUT 2,N:CLS:GOTO 50
200 N=N+1:GET #1,N:GET #2,N:IF N>(LOF(1)/16) THEN END
210 B=CVI(B$):G=CVI(G$):Y=CVI(Y$):O=CVI(O$):C=CVI(C$):R=CVI(R$):A=CVI(A$):
AG=CVI(AG$)
220 PRINT N,ID$:GOTO 200
```

LISTING 2—IDENTIFICATION PROGRAM

```
1 'IDENTIFY.BAS  identification program
10 ADR=512:OUT ADR,255:PRINT:INPUT "Hit Enter To Scan/Identify Unknown
Color";A
20 IF A=9 THEN RUN"fcal"
30 ERP=1E+20:OPEN"R",1,"cal1",16
40 FOR H=0 TO 7:K=0:IF H<7 THEN Z=2^H ELSE Z=194
50 OUT ADR,Z: FOR I=1 TO 500:NEXT I
60 FOR J=1 TO 50:K=K+INP(ADR):NEXT J
70 IF H=0 THEN BU=K ELSE IF H=1 THEN GU=K ELSE IF H=2 THEN YU=K
80 IF H=3 THEN OU=K ELSE IF H=4 THEN CU=K ELSE IF H=5 THEN RU=K
90 IF H=6 THEN AU=K ELSE IF H=7 THEN AGU=K
100 NEXT H:BEEP
110 OUT 512,255:OPEN"r",2,"cal2",24:FIELD 1,2AS B$,2AS G$,2AS Y$,2AS O$,2AS
C$,2    AS R$,2AS A$,2AS AG$:B=LOF(1)/16
120 FOR N=1 TO B:GET #1,N:IF ABS( CVI(B$)-BU)>400 THEN 140
130 ER=(CVI(B$)-BU)^2+(CVI(G$)-GU)^2+(CVI(Y$)-YU)^2+(CVI(O$)-OU)^2+(CVI(C$)-
CU)^    2+(CVI(R$)-RU)^2+1*((CVI(A$)-AU)^2)+2*((CVI(AG$)-AGU)^2):IF ER<ERP
THEN ERP=    ER:NN=N
140 NEXT N
150 FIELD 2, 24AS ID$: GET #2,NN
160 CLS:PRINT "Best Color Match",ID$:PRINT"Relative Error",ERP:PRINT"reference
number",NN:RUN
```

To create the calibration files, run CALIBRAT.BAS. The program will ask you to enter the name of a standard, or press "e" to end calibration. If you enter "e," the program will end, displaying a list of currently calibrated color standards. Otherwise, it will create a new standard using the name you entered. It creates the standard values by enabling each LED (or the LED2/LED6 combination) in turn, then reading 50 times in succession the value sensed by Q1. Each color value (which is summed in variable K) is plugged back into the appropriate field of the data file in lines 110–180, then written to disk in line 190. If you want to re-do a standard value, enter "n" at the prompt. The program will ask you the numerical value of the standard you want to re-do, and then update the appropriate numerical values.

To identify an unknown color, run IDENTIFY.BAS. As in the calibration program, IDENTIFY samples each LED (or combination) 50 times and sums the results. The program then compares the sum against the values stored in the standard file and finds the closest match. The program calculates error as the sum of the squares of the differences, with double weighting given to the dual (aqua/green) LEDs. On a 20-MHz 286-based PC, it takes less than three seconds to determine the closest match from a list of 1000 values.

Construction

The authors built the prototype on two cards. One is an interface card that can be inserted in any standard 8-bit PC expansion slot. This card contains everything except the LEDs and phototransistor. They are located in a separate box called the reflectance probe; it connects to the interface card via a 12-conductor ribbon cable.

To save money, the authors built the interface card on a $4.99 72-pin prototype card. If you use the specified interface card (see the Parts List), *carefully* file exactly ½" from the edge connector to make it fit the 62-pin PC slot. The complete board should appear as shown in Fig. 2. (Note that the authors split the cable in two, attaching the separate sections with a pair of 25-pin, D-style, I/O connectors.)

Figure 3 illustrates the reflec-

PARTS LIST

All resistors are ¼-watt, 5%, unless otherwise noted.

R1—10,000 ohms
R2—470,000 ohms
R3—220,000 ohms
R4, R10—4700 ohms
R5—1200 ohms
R6—330 ohms
R7—47 ohms
R8—15,000 ohms
R9—470 ohms

Capacitors

C1—220 pF disk capacitor
C2—0.1 μF disk capacitor

Semiconductors

D1—1N4148 diode
IC4—7406A hex inverter with open collector outputs
IC1—74HCT688E octal comparator
IC3—74LS533E octal latch with inverted outputs
IC2—ADC803LCN analog-to-digital converter (Burr-Brown)
IC5—7805 5-volt regulator
LED1—470 nm blue LED (DigiKey 103CR-ND or equiv.)
LED2—560 nm green LED (DigiKey P312 or equiv.)
LED3—590/700 nm yellow/red LED (DigiKey P394 or equiv.)
LED4—565/630 nm green/orange LED (DigiKey P509 or equiv.)
LED5—665 nm crimson LED (DigiKey P405 or equiv.)
LED6—482 nm aqua LED (Ledtronics, Torrance, CA, L200CWGB6 or equiv.)
Q1—phototransistor (Digi-Key PN168PA-ND or equiv.)

Miscellaneous: 14-pin DIP socket (1), 20-pin DIP sockets (3), 5-foot length of 14-conductor ribbon cable, box (Radio Shack 270-230 or equiv.), plug-in PC board (Radio Shack 276-192 or equiv.), hookup wire, wire cutters, soldering iron, solder, drill, ½" drill bit, small drill bit, file, glue gun, and black plastic electrical tape.

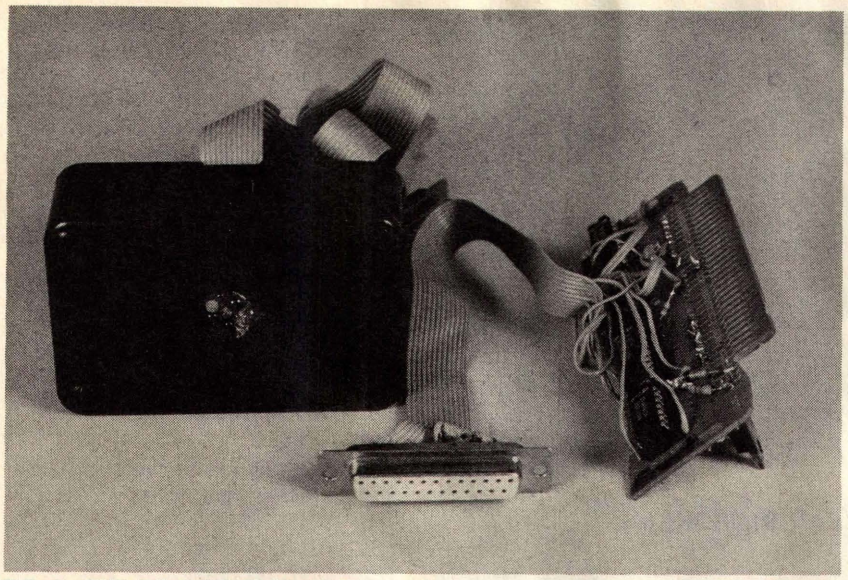


FIG. 2—THE PC INTERFACE CARD requires just enough space for five ICs, ten resistors, a couple of capacitors, and a diode. The reflectance probe contains six LEDs and the phototransistor cemented together with hot-melt glue and sealed in a light-tight box.

tance probe, which contains the six LEDs arranged in a circle around the phototransistor. All components are mounted on perforated construction board, which could be removed from the top of the interface card. Each LED must be tilted so that the brightest emission from each LED illuminates the sample and reflects back into the phototransistor. Tilt angle is particularly critical for the blue LED.

Glue a 6-centimeter (cm) piece of perforated construction board into the bottom of the box with the solder pads up. Then drill a small pilot hole, followed by a larger ½ inch hole, through both the board and the box, in the approximate center of the box. Cut the shorter leads of the LEDs and phototransistor to about a 1 centimeter length, and the longer leads to about 1.5 cm. Spread the phototransistor leads 180° and solder the phototransistor so that it points straight out the center of the hole. Now solder in the LEDs. All devices should be almost flush with, but not protrude through, the bottom of the box.

Connect all the common LED leads and the collector of the phototransistor to a common +5-volt line. Connect the remaining LED and phototransistor leads to the individual wires of the ribbon cable.

Testing and final assembly

Test the unit before gluing the optics in place. First check all wiring carefully. An inadvertent wiring error or short circuit could cause your PC to crash, or even damage it. Turn off PC power, install the circuit card, turn the power back on, and start BASIC. By typing a series of statements in the following form, you should see each LED light up in turn.

```
out (512,n)
```

where 512 is the address at which you wired IC1 to respond (default = 512), and N is 1, 2, 4, 8, 16, 32, or 64, which should in turn illuminate the blue, green, yellow, orange, crimson, red, or aqua LED.

Now run the calibration program (Listing 1) and calibrate a few values. Next run the IDENTIFY program (Listing 2) and verify that the unit works. Read the usage notes before concluding that it doesn't work.

When you're satisfied that it works correctly, seal the LEDs and phototransistor in the box with hot-melt glue. Attach the cover on the box with screws, and seal the box with electrician's black vinyl tape to prevent stray light from leaking in and corrupting the results.

Usage notes

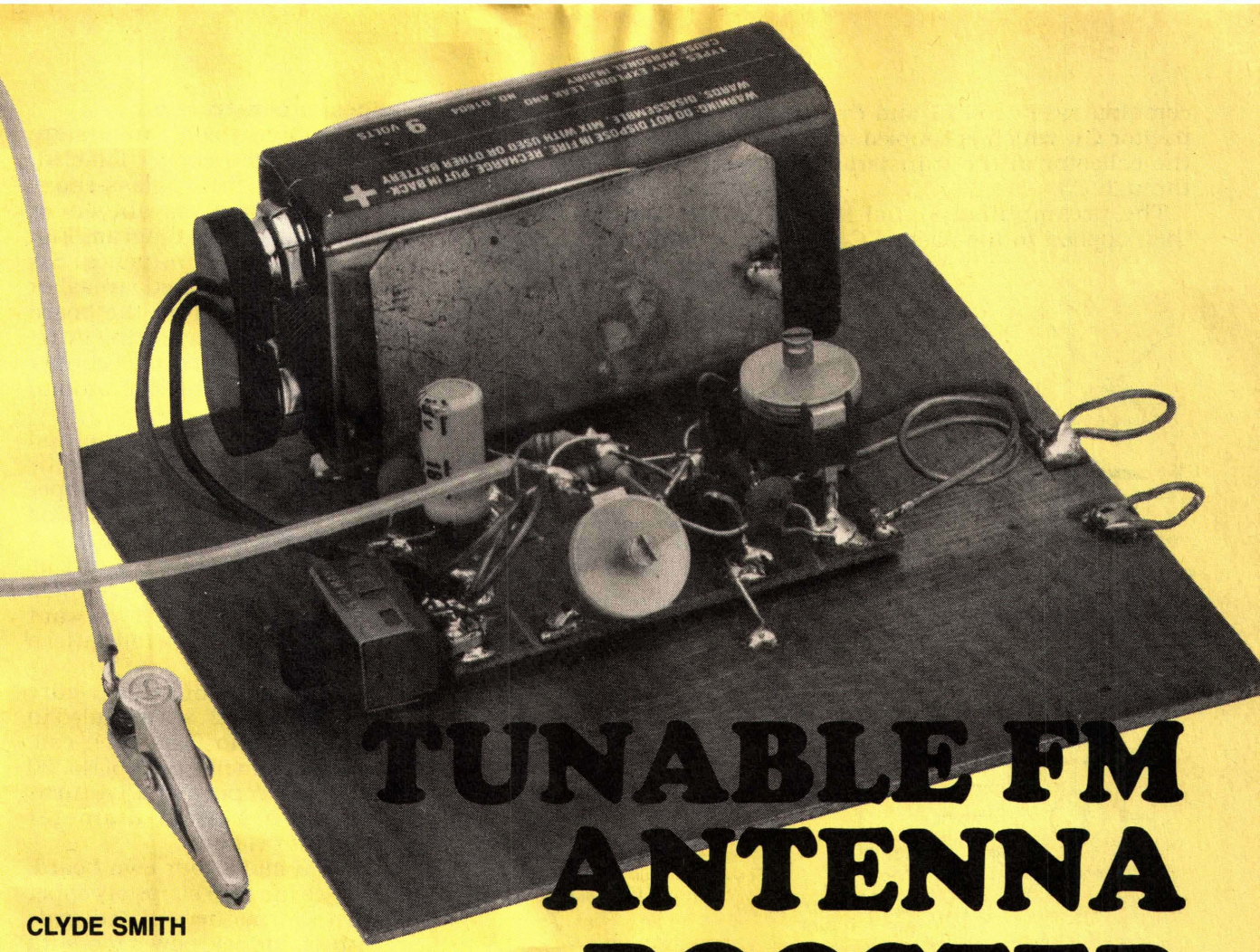
Thermal stability is an issue with this circuit. You should always turn it on several minutes before using it. The larger the number of standard colors you have defined, the longer you should let the tester warm up. The authors found that with a 1000-sample standard file, a warm-up time of one hour was required for accurate results. The authors also found that the best thermal stability was achieved by leaving the LEDs on. This is the reason for the OUT ADR,255 instructions in the initialization sections of both programs. Of course, during a scan, the software turns on only one LED at a time.

The methodology paid off. After it was calibrated, the authors' prototype was able to identify 900 shades of Sears' standard paint colors, plus an additional 100 "Weatherbeater Premium" paint sample colors. In addition, the circuit gives reasonable matches for typical random color samples. For example, the best match to the blue background on page 37 of the September 1992 issue of *Radio-Electronics* was identified as "Oriental Blue."

Magazines typically print colors as discrete dots of a specific color, not as continuous tones. Under normal circumstances, the dots shouldn't affect the color-matching process. If the dots are very large, or if for any other reason you have trouble getting consistent results, try covering your sample with a thin sheet of clear plastic.

"Gloss" and texture are, however, subjects of concern. Samples with slight texture or gloss can usually be matched fairly well, but don't use textured, glossy, or plastic-covered samples for calibration.

Identifying 1000 colors with 100% accuracy is an impressive feat for so simple a device. We hope that someone will develop the idea further by improving the statistics, writing the software in a language more powerful than BASIC, developing a serial (RS-232) version for laptop computers, and even a pocket-size EPROM version. Ω



TUNABLE FM ANTENNA BOOSTER

CLYDE SMITH

Build this FM booster and enjoy broadcasts from distant FM stations that you've never been able to receive.

HAVE YOU EVER HAD DIFFICULTIES in picking up or holding on to distant FM stations that were broadcasting programs you wanted to hear? Or maybe you know there are more distant stations out there that are beyond the range of your receiver. You could, of course, buy or build a better FM tuner. However, by building a tunable FM booster you will both save money and dramatically expand your FM listening reach.

It's true that factory-made FM boosters are available from electronics stores and mail-order houses, but they can cost as much as $50. By contrast, the parts for our FM booster cost less than half that amount. The project should take only a few hours to complete, and you have many options for packaging the two-stage amplifier circuit.

You'll be amazed at the gain of this little circuit. The prototype has picked up stations more than 150 miles from the receiver! You'll need an indoor rabbit-ear antenna as shown in Fig. 1. The antenna is connected to the input side of the booster, and the boosted signal is sent via a single wire to the retracted antenna of the FM radio. Some simple adjustment procedures will be required after you hook up the circuit.

This FM booster improves selectivity when it is precisely tuned to a desired station that is close to others in frequency—a feature not found in broadband units. This selectivity is especially important for battery-powered, portable, Walkman-type receivers or low-performance FM receivers. This circuit also boosts weak signals to a stereo lock-on level. However, when you are listening to strong local stations, you'll want to switch the booster off to prevent audio "swamping."

Circuit description

The booster circuit, whose schematic is shown in Fig. 2, is a two-stage radio-frequency amplifier. It includes two 2N3904 NPN transistors, Q1 and Q2, capable of 250-MHz operation. The signal from the rabbit-ears is fed to the first stage at the base of Q1, which is biased for optimum gain by R1. The circuit is tuned to the incoming signal frequency by the

combination of coil L1 and capacitor C1, which is coupled to the collector of the transistor through C3.

The preamplified signal is then applied to the base of Q2 through C4. The components in the second stage are identical to those in the first stage, and its frequency is determined by L2-C2 in the collector circuit. The fully amplified RF signal is then fed to the antenna of the FM receiver from the junction of L2-C2 with an insulated wire about 8 inches long terminated with an alligator clip. If the FM receiver has a telescoping antenna, collapse it to its retracted position.

The tunable FM booster is powered by a standard 9-volt transistor battery through switch S1. Capacitors C6 and C7 across the battery input perform filtering and stabilization on the power supply.

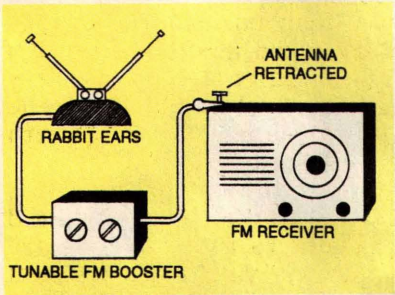


FIG. 1—TUNABLE FM BOOSTER is connected between rabbit ears and retracted antenna of FM receiver.

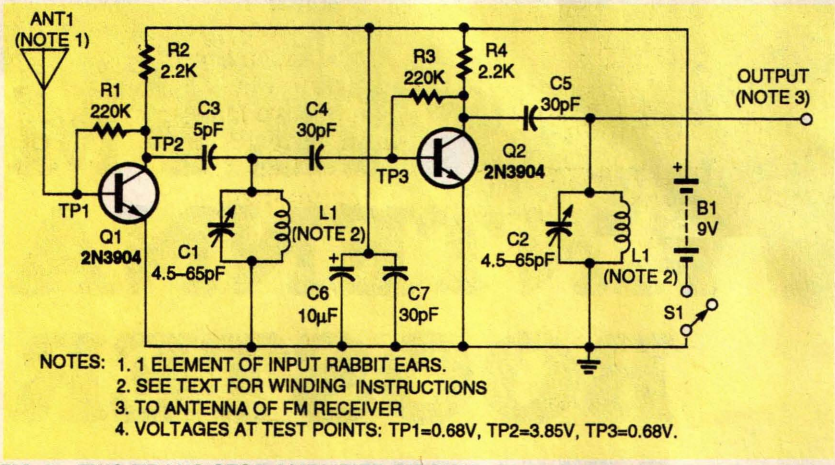


FIG. 2—TWO-TRANSISTOR AMPLIFIER CIRCUIT with tunable tank circuits boosts the distant FM signals.

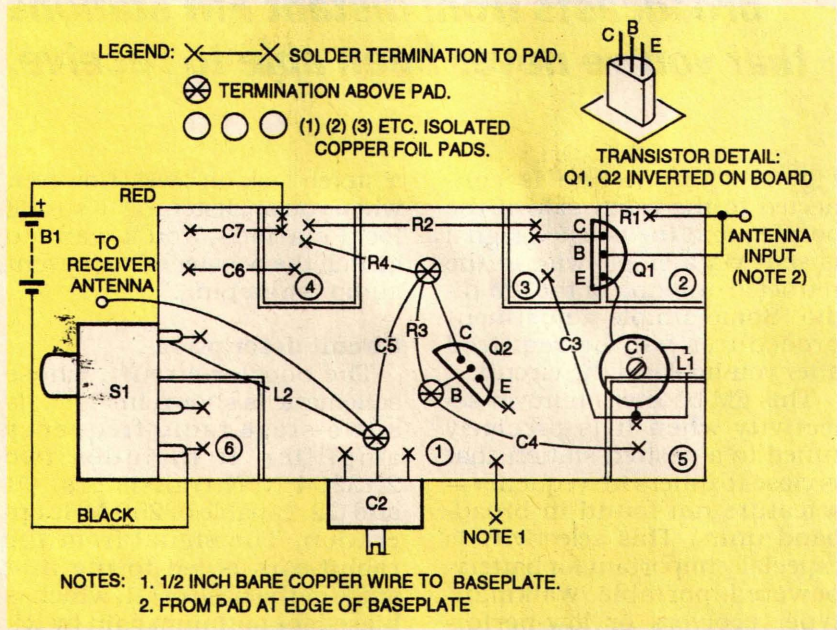


FIG. 3—PARTS PLACEMENT DIAGRAM. Components are soldered to pads on copper-clad board. Notice that the transistors are inverted.

Booster construction

The circuit components are mounted on a copper foil-clad, 0.040-inch thick, glass-epoxy circuit board, as shown in parts-placement diagram Fig. 3. It is cut 1½×¾-inches. Six electrically isolated areas or pads are formed on the board for component mounting by removing thin strips of copper down to the substrate around the pads.

This construction method permits the components to be soldered securely to the copper foil of the board without drilling any holes in the board. A finished circuit board can be obtained from the source listed in the Parts List, but if you want to make your own, a foil pattern is included here.

Two hand-wound, air-core coils, L1 and L2, are included in the circuit. To form each coil, wind a 2½-inch length of No. 20 AWG bare copper wire 1½ turns around a ⅜-inch diameter dowel or drill bit.

If you make your own board, remove the thin strips of copper foil to form the isolated pads with a handheld power tool with either a fine abrasive disk or circular saw in the tool chuck. You can also remove the copper manually by making parallel scores around the outlines of each pad with a sharp razor knife and carefully lifting out the thin strips between the scored lines.

Regardless of the method you use, inspect the fine channels with a magnifying glass and, with an ohmmeter, verify that there are no copper burrs between the isolated pads that could form an unwanted electrical path between them.

Position the leaded components as shown in parts placement diagram Fig. 3. The numbers on the diagram match the numbered pads on the circuit board. The "X" marks on the diagram indicate where lead terminations are to be soldered directly to the copper-foil pads, and the three stars indicate where lead terminations are to be soldered above the board, without making any contact with it.

PARTS LIST

All resistors are ⅛-watt, 5% carbon film
R1, R3—220,000 ohm
R2, R4—2200 ohm
Capacitors
C1, C2—4.5 to 65 pF variable trimmer, Sprague-Goodman or equivalent.
C3—5 pF disc
C4, C5, C7— 30 pF
C6—10μF, aluminum electrolytic
Semiconductors
Q1, Q2—2N2904 NPN transistor (TO-92 package)
Other components
L1, L2—air core RF coils (see text)
S1 —miniature slide switch, SPDT
Miscellaneous: Rabbit-ear antenna with telescoping conductors, 1½ × 3-inch PC board (see text), 3 × 3-inch ground plane (see text), 3 miniature alligator clips, 9-volt battery clip assembly, insulated No. 22 AWG wire, bare No. 20 bare copper wire, 9-volt transistor battery, optional case, solder.
Note: The following items are available from Smith Kits, Route 2, Box 756, Salem MO 65560
- **Kit of all components and finished PC board except antenna, ground plane, and case—$19.95**
- **Finished PC board—$3.00**

Add $1.50 for shipping and handling. Missouri residents add local sales tax to all orders.

Notice that both transistors Q1 and Q2 are soldered in inverted positions. Solder the black and red leads from a 9-volt battery clip to the locations shown in Fig. 3. Cut an 8-inch length of insulated, stranded wire, trim the insulation from both ends, and solder one end to the junction of the leads from C2, C5, and L2.

After completing all soldering on the circuit assembly, check carefully at the points marked with the star to verify that no bare leads entering or leaving those junctions are in contact with any copper pads. Increase the spacing of the junctions above the board with a thin tool if they are too close to any copper pads.

Make a bracket for the 9-volt battery by cutting a 2½ × 1½-inch piece of tin-coated steel from a flattened can. File the edges to remove any sharp burrs, and file a slight radius on each sharp corner to round it off. Then bend up the ends of the metal up 90° along the dotted line to form a "U-" shaped channel. Leave a ⅝-inch spacing between the side pieces for inserting the battery.

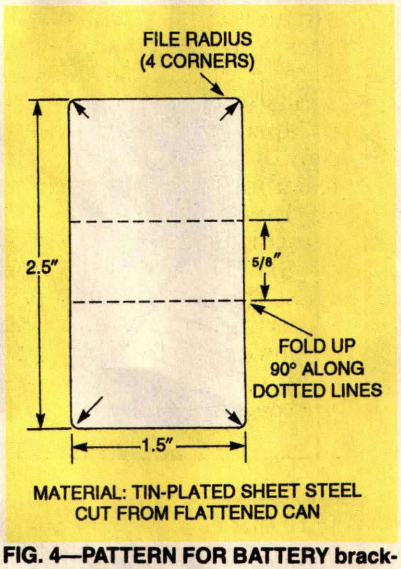


FIG. 4—PATTERN FOR BATTERY bracket cut from can metal.

Cut a second 3-inch square piece of copper foil-clad board for a ground plane, as shown in Fig. 5. Form an isolated ¼-inch copper foil pad with the method previously used along one edge of the board, as shown. Position the amplifier circuit assembly in a central position on the ground plane, and mark it with a pencil or felt-tip pen.

Solder the battery-mounting bracket to the 3 × 3-inch board adjacent to the circuit board "footprint" with solder beads at each end of the bracket channel. Then position the circuit assembly on the ground plane and solder a bare copper wire jumper from pad No. 1 on the circuit assembly to the plane, as shown in Fig. 5.

Form two loops from about 1-inch lengths of bare copper wire. Then solder a 1½-inch length of insulated, tinned cop-

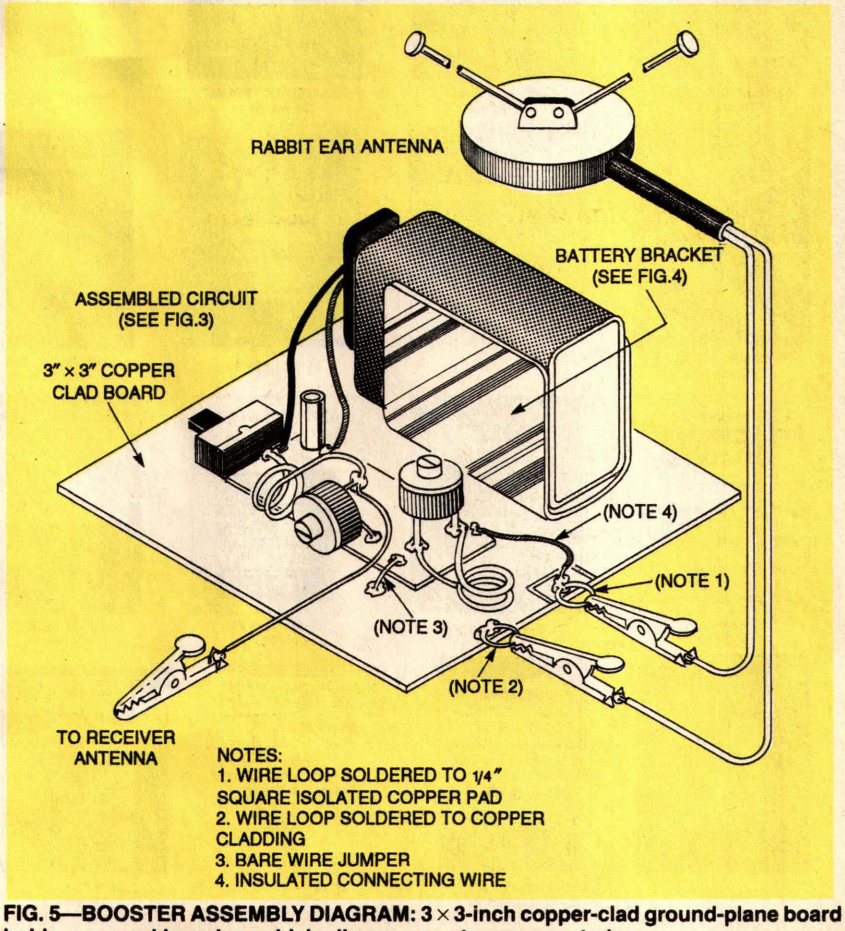
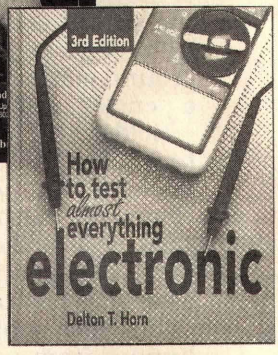
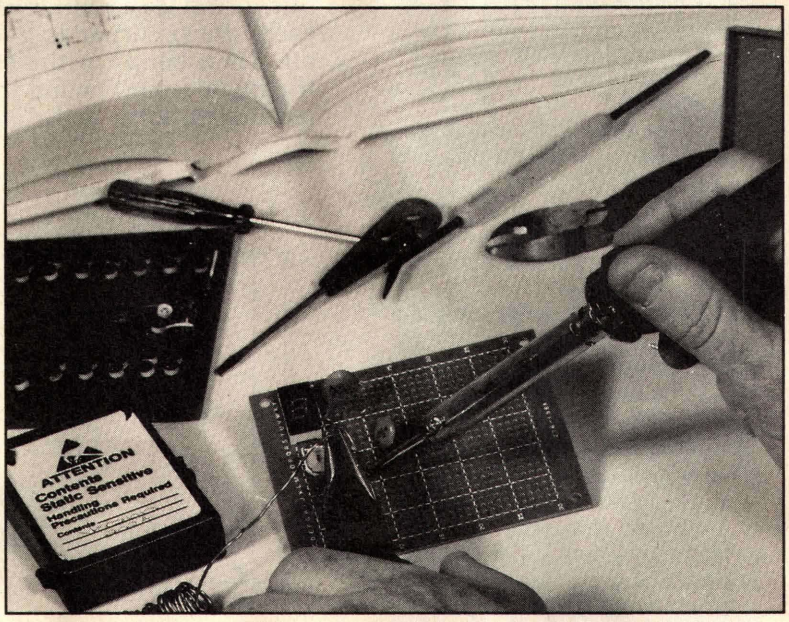


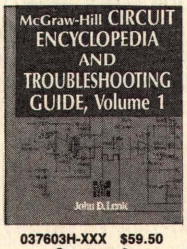
FIG. 5—BOOSTER ASSEMBLY DIAGRAM: 3 × 3-inch copper-clad ground-plane board holds a second board on which all components are mounted.

4089P $18.95
Softcover

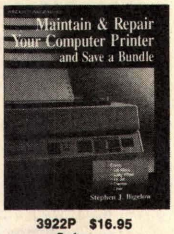


4227P $14.95
Softcover





037603H-XXX $59.50
Counts as 3



3922P $16.95
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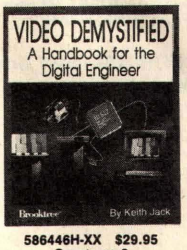
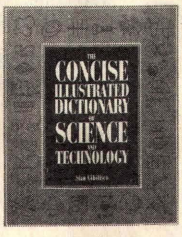
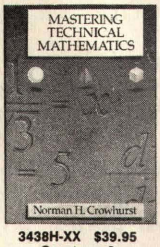


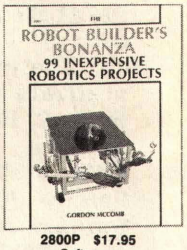
586446H-XX $29.95
Counts as 2



3715H $36.95



3438H-XX $39.95
Counts as 2



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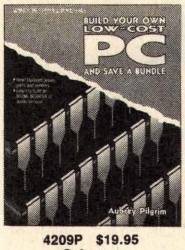

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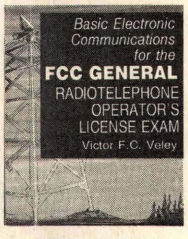

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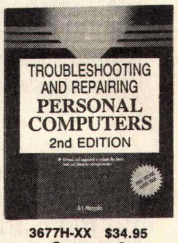

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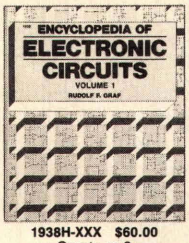

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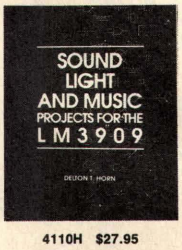

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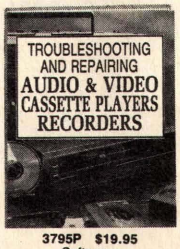

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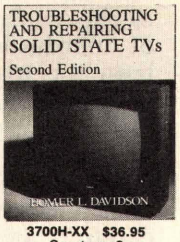

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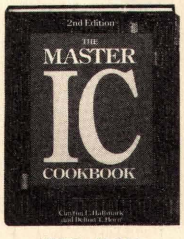

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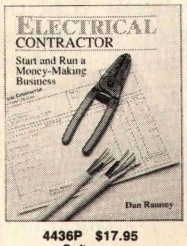

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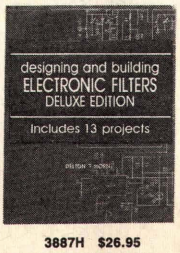

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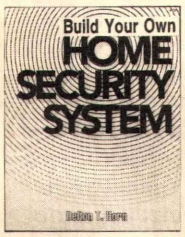

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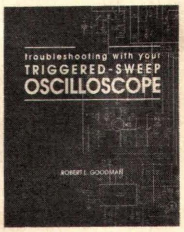

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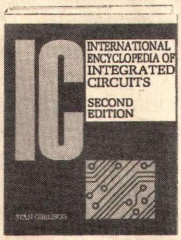

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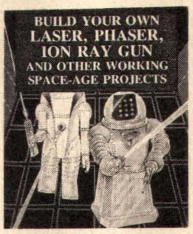

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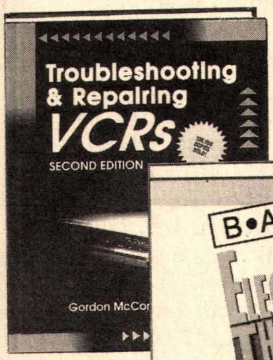

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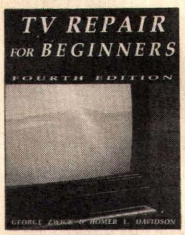

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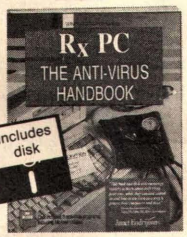

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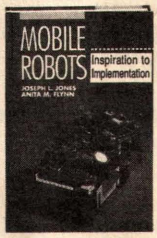

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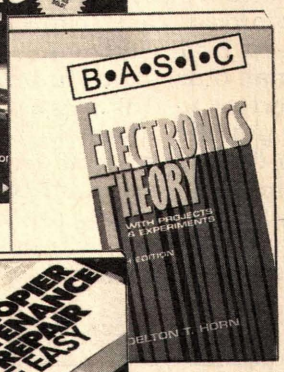

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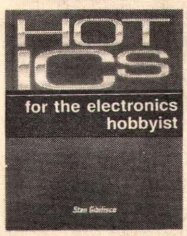

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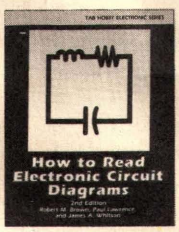

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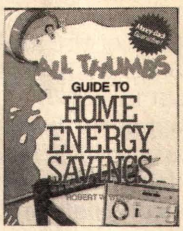

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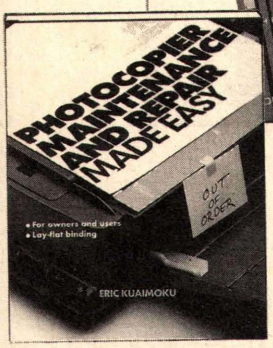

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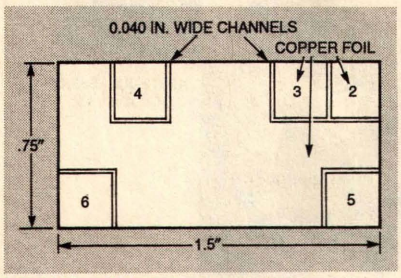
per wire from pad No. 2 on the circuit board to the pad on the edge of the ground plane while simultaneously soldering one of the copper loops to the pad. Then solder the second copper loop to a location adjacent to the pad, as shown in Fig. 5.

Solder miniature alligator clips to the terminations of the twin-lead from the rabbit-ear antenna, and solder an alligator clip to the end of the wire to the FM receiver antenna.

You might want to house the completed miniature circuit in a protective plastic case. Suitable project cases can be purchased from electronics stores or mail-order distributors that advertise in this magazine. If you put the circuit in a case, drill the holes for all external connecting wires and two access holes to tuning capacitors C1 and C2 before you position the assembly in the case.



CIRCUIT-BOARD FOIL PATTERN. Slits in the copper foil expose the insulating substrate.

The board can be fastened inside the case with beads of RTV silicone adhesive on the corners of the underside of the ground plane. You might also want to substitute small wire binding nuts and bolts for the wire loops on the ground plane for making the rabbit-ear antenna lead connections.

Be aware that the tunable feature of the booster increases gain, but it can also cause oscillation because the circuit is not neutralized. This drawback can be surmounted by placing and soldering circuit components precisely according to the parts placement diagram in Fig. 3 and closely following the adjustment procedures and any other suggestions that are given here.

Adjustment procedures

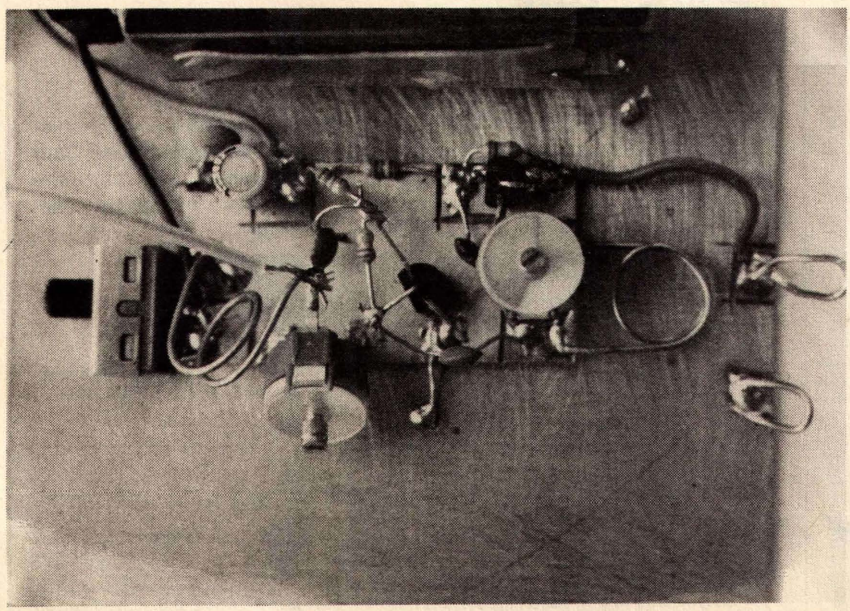
Perform the following adjustments:

1. Extend the rabbit ears to their limits, and position them with a separation angle of about 90°.
2. Connect the antenna leads to the 3 × 3-inch ground plane as shown in Fig. 5.
3. Switch the booster switch S1 OFF and the FM receiver's switch ON with its volume control set at a middle position.
4. Clip the alligator clip to the tip of the retracted antenna on the FM receiver, and tune to a station near midband that is barely audible. Avoid loud, overpowering local stations that will make the adjustment procedures more difficult than is necessary.
5. Adjust capacitors C1 and C2, and then orient the rabbit ears until you obtain maximum output from the selected station. If the station is broadcasting in stereo, the stereo indicator should indicate when signal strength is at its maximum.
6. Turn switch S1 ON, and if the booster is working properly, you should hear an increase in signal strength. If the circuit is not working properly, measure the voltage at the points shown on schematic Fig. 1 with a voltmeter, and compare the readings with those shown on the schematic.
7. If signal strength decreases, the amplifier might be oscillating or it might be mistuned. Adjust C1 and C2 very slowly to obtain the clearest signal; repositioning the antenna while observing the stereo indicator might also prove helpful in obtaining the most optimum signal possible.
8. Repeat the preceding steps for each FM station of interest. Once you adjust the booster for one position of the band, others within 10 to 20 MHz should be received as well. Some tweaking of C1 and C2 might be necessary to achieve this result. Be patient until you get the knack of maximizing gain—after some experimentation, you should get it right.

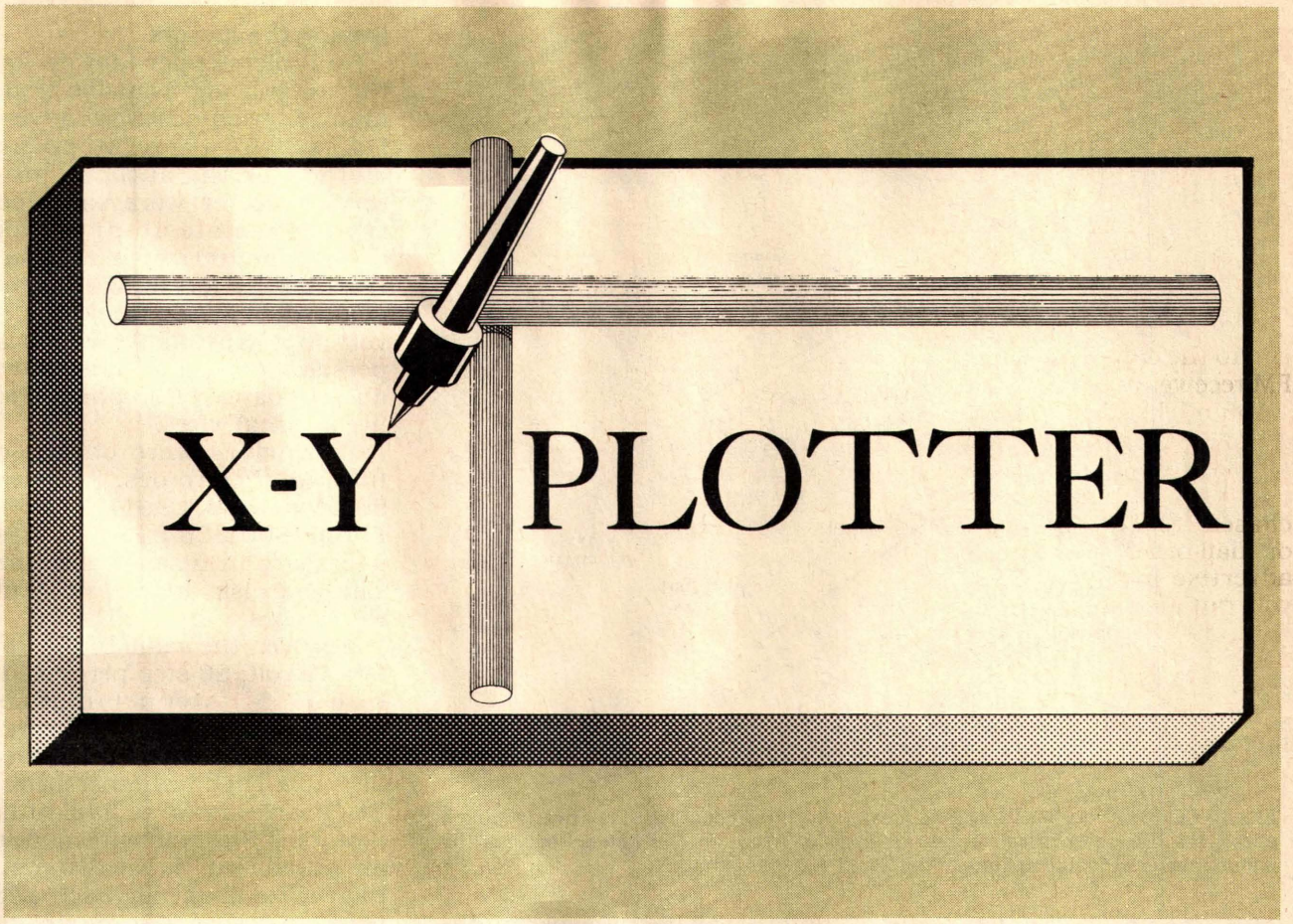
Adjustment suggestions

The receiver must be tuned exactly to the station frequency. However, if the desired results are not obtained, alternately shorten one rabbit ear dipole or the other while changing the orientation or angle between the elements.

If you use the booster with a portable receiver in a fixed location, clip the booster output lead to the earphone wire insulation near the jack. Be patient and this circuit will reward you with many hours of listening enjoyment. Ω



COMPLETED CIRCUIT ASSEMBLY mounted on the ground plane. The battery is at the top of the picture.



Build this X-Y plotter for your PC and plot curves, draw circuit-board patterns, create artistic designs, and even do lettering!

JIM BROWN

HAVE YOU EVER WANTED AN X-Y plotter for your personal computer but been discouraged by the high price of a factory-made unit? Here is your chance to build your own plotter, learn the fundamentals of computer-based plotters, and save money.

This plotter can draw lines, curves, complex patterns, and alphanumeric characters with a pen on paper. It can also plot mathematical functions and even draw printed-circuit board foil patterns. If a cutter is installed in the tool holder in place of the pen, the plotter can cut adhesive-backed sheet vinyl to form uniform letters, numbers, or patterns.

The simplified diagram of the plotter mechanism shown in Fig. 1 shows how it translates the rotary motions of two stepper motor shafts into linear motions under computer control. The plotter assembly consists of X and Y stepper motors and sliding X and Y motion translation arms mounted on the rigid wooden board that is the plotting surface.

The X motor moves the tool left and right on the board along the X axis, and the Y motor moves the tool up or down on the board along the Y-axis. A sliding component that consists of two bearings and a tool holder resolves the simultaneous motions of the X and Y axes and moves the pen or cutting tool in two degrees of freedom to trace the resulting pattern.

A third or Z-axis stepper motor shown in the more detailed drawing, Fig. 2, lifts the tool holder from the plotting surface under computer control. A crank arm on the motor shaft hauls up on a cord attached to a "drawbridge" mechanism that lifts a hinged arm supporting the X and Y mechanical elements. Z-axis motion occurs when the motor shaft is stepped through a partial revolution.

This simple motion-translation mechanism is suitable only for light-duty plotting or cutting. It avoids expensive gears, drive chains or lead screws. As can be seen in Fig. 2, the mechanism includes tee-shaped X-axis and Y-axis arms or frames. Each frame consists of a base rod with a translation arm rigidly fastened perpendicular to it. Each base rod is supported at both ends by a combined standoff and sleeve bearing.

The sleeve bearings permit the base members to move only in one degree of freedom—parallel to the X or Y axes. As a re-

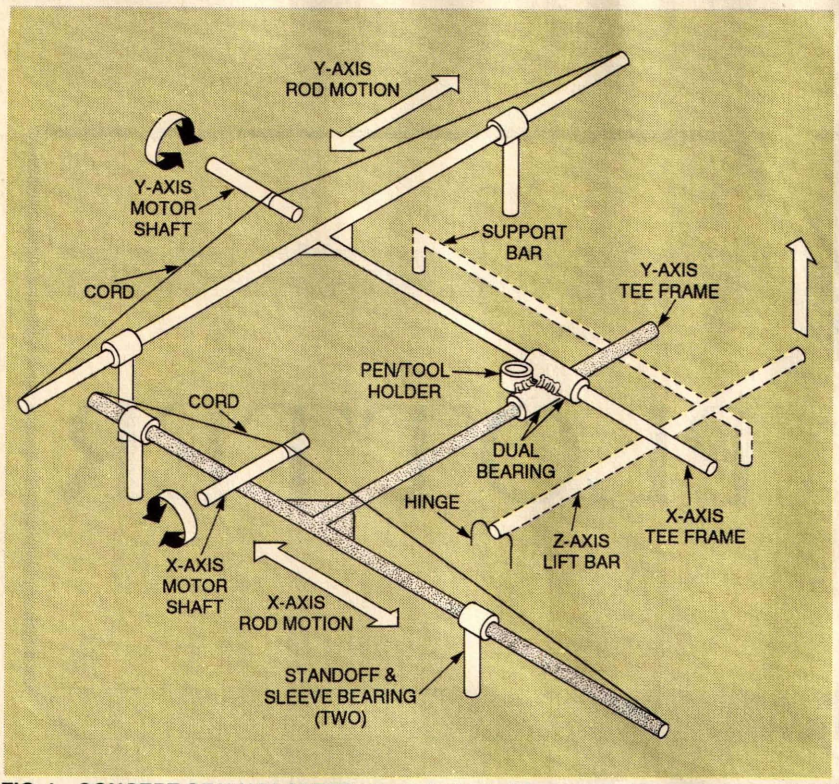


FIG. 1—CONCEPT OF X-Y PLOTTER. A pen in the holder coupled to two overlapping X and Y tee frames is driven in two degrees of freedom. The holder resolves the simultaneous winching actions of the X and Y stepper motors.

sult, the perpendicular X-axis and Y-axis motion translation arms follow the motions of the base members.

The base rods for both the X and Y axes are moved in their respective directions by cord wrapped around the stepper motor shafts and terminated at the ends of the base members. In effect, the shafts "winch" each tee fame back and forth over precise linear distances under computer control.

The overlapping translation arms on each tee frame are constrained by a part consisting of two sleeve bearings with an attached tool holder. The two sleeve bearings are joined, one over the other, with their axes 90° apart and the tool holder is fastened at right angles to both bearings.

Precise construction details have been deliberately omitted from these drawings to give the reader the opportunity to experiment and build an assembly that is within his or her capabilities. It is important that all of the mechanical parts be as light and strong as possible, and that all bearings permit the supported parts to move freely.

Stepper motors

A stepper motor is classified as a DC motor, but it is actually an AC motor driven by a train of pulses. The rotors of these motors move or are indexed through a carefully controlled fraction of a revolution each time they receive an input step pulse. This permits shaft movement to be controlled precisely, which in turn permits precise and repeatable pen or cutting tool movement.

Electronically counted input pulses provide this controlled motion without the need for an error correcting closed-loop feedback circuit. The shafts of the light-duty stepper motors selected for this project will turn through a complete revolution with the application of either 50 or 100 pulses. Each pulse to the 50-pulse motor moves the shaft in 7.5° increments. However, each pulse to a 100-pulse motor moves the shaft in 3.6° increments, providing much greater precision.

Buying the motors

Suitable stepper motors for this project are available from many *Electronics Now* advertisers. The three stepping motors for the author's prototype plotter were salvaged from obsolete floppy-disk drives. The 100 step per revolution (3.6°) motors draw 0.16 amperes when driven from the 12-volt supply available within a personal computer. They have an impedance of 75 ohms and five external wires.

The drives were obtained from All Electronics, P.O. Box 567, Van Nuys, CA91408-0567, Phone 800-826-5432. It was necessary to disassemble the salvaged disk drives to obtain the motors.

However, the same source offers 12-volt, 50-step per revolution (7.5°) stepper motors which do not have to be removed from a salvaged drive, but at a slightly higher price. They are six-wire, 35-ohm motors. If these six-wire models are purchased, tie the two common wires (typically back and white) together to form a common power connection.

The first stepper motors in 360-Kbyte floppy-disk drives had five wires; one is the ground or common wire and four are pulse wires. The functions of the pulse wires can be verified with a 9-volt battery with leads atached. Connect the negative lead to the black wire, and in a 1, 2, 3, 4 sequence, touch each of the other four wire ends with the wire from the battery's positive terminal.

Whenever you connect the positive lead to one of the four wires, the shaft of the stepper motor will move incrementally. These stepping motors step 3.6° with each input pulse. However, some motors must be energized in a 1, 3, 2, 4 order. To reverse the shaft direction, the motor is stepped in reverse order: 4, 3, 2, 1 or 4, 2, 3, 1, depending on how the motor is wound.

Building the plotter

The recommended size for the square plotting board based on the torque limitations of the stepper motors is about one foot

on a side. The prototype board was made from ½-inch thick plywood, but any rigid, smooth base would be suitable.

Cut the X-Y plotting board to that size, and sand its edges and corners to prevent splintering. Draw the "footprints" of the three stepper motors in the positions and with the orientations shown in Fig. 2. This will permit you to estimate the size of the available plotting area. (An area of 8½ × 8½ inches should be satisfactory.)

Fasten both the X-and Y-axis stepper motors at the edges of plotting board at their mid points as shown in Fig. 2. One simple way to mount the motors securely on the plotting board is as follows:

Form two inverted "U"-shaped sheet-metal straps with bent tabs at each end. Drill holes in the tabs to accept wood screws, and fasten the motors to the boards with their shafts parallel to the board, as shown in Fig. 2.

Form an "L"-shaped crank arm from a piece of thin-walled copper or brass tubing about 3 inches long. Drill a hole in one end for fastening the Z-axis "drawbridge" cord. Fasten the arm to the shaft of the Z-axis motor by soldering or epoxy. Drill holes in the plotting board to align with holes in the mounting bracket of the Z-axis motor so that it can be mounted in a vertical position. With suitable screws, fasten the motor, as shown in Fig. 2, with the crank arm of the motor directed as shown.

With the X, Y and Z motors mounted, determine the dimensions of the X and Y tee frames or arms. The base rods should be approximately twice the length of the available plotting surface. The tee frames in the author's prototype were made from hardwood dowels that were hot-glued perpendicular to each other. However, thin-walled brass tubing that can be soft-soldered will work just as

PARTS LIST

Semiconductors

IC1—8255A-5 programmable periphial interface, Intel or equiv.

IC2—74LS138 1 of 8 line decoder/demultiplexer, Motorola or equiv.

IC3, IC4—ULN2803 high-voltage, high-current Darlington array, Allegro Microsystems or equivalent

Other Components

MOT1, 2, and 3—stepper motor, 100 pulse per revolution, 3.6° (See text)

Miscellaneous: IBM PC/XT 8-bit plug-in prototype board (see text), No. 22 AWG insultated wire in a variety of colors, plywood (1 ft × 1ft, ½-inch thick), appropriate materials for constructing standoffs, bearings and moving tee arms and other mechanical parts, 15-pin connector, heavy-duty nylon cord, plug and socket, epoxy, solder.

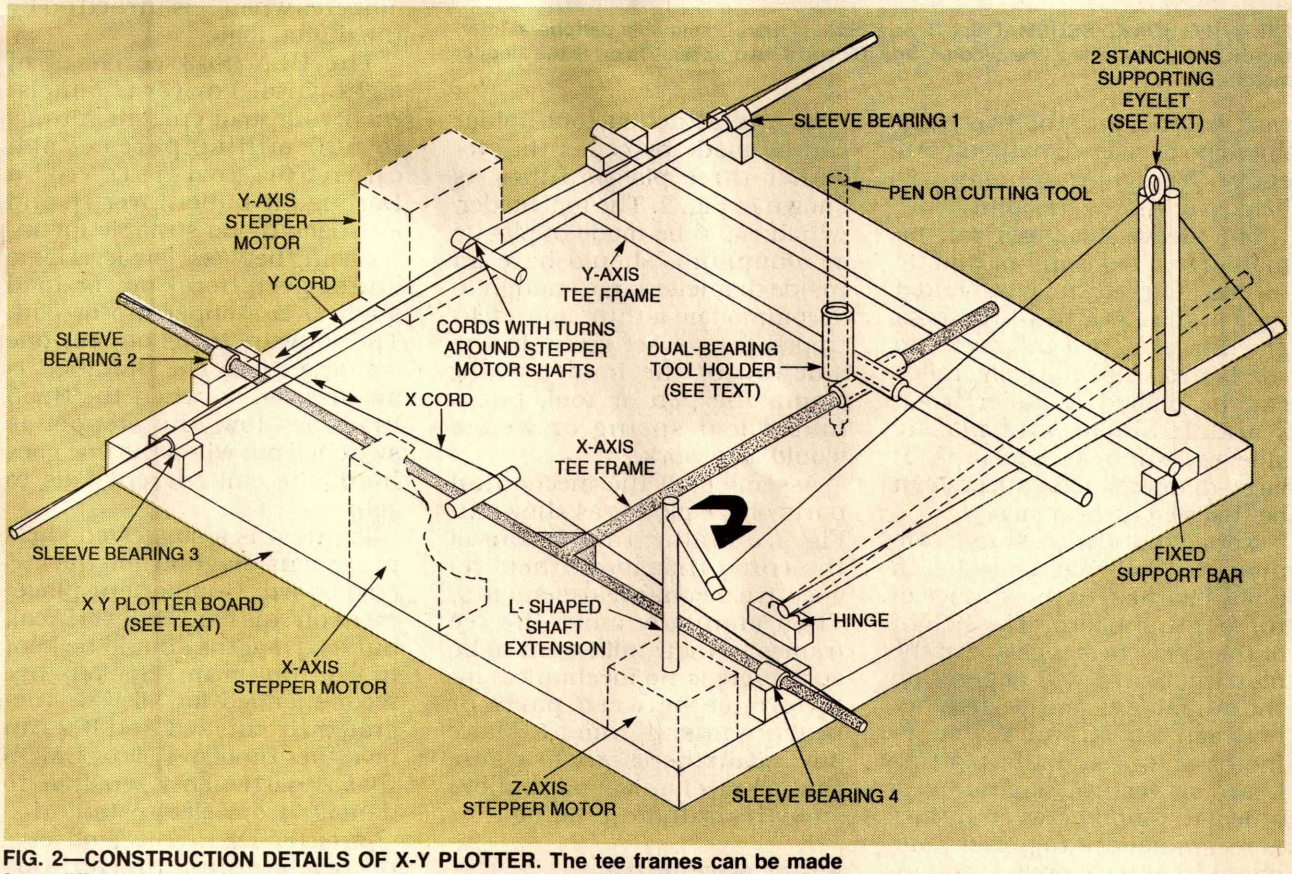


FIG. 2—CONSTRUCTION DETAILS OF X-Y PLOTTER. The tee frames can be made from different kinds of light, strong materials, but they must be slide easily in their sleeve-bearing supports without binding. The vertically mounted Z-axis motor lifts the X and Y arms and tool holder when a crank arm pulls on the cord attached to the side rail.

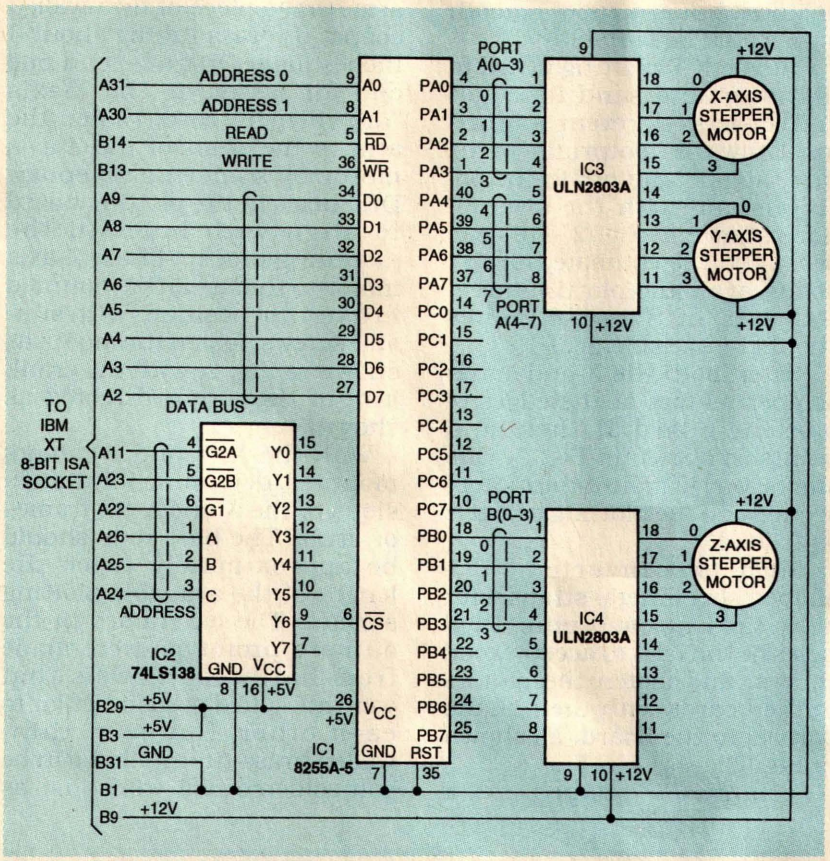


FIG. 3—I/O BOARD SCHEMATIC: IC1, an 8255A, is a programmable peripheral interface, IC2, a 74LS138 is a line decoder, and IC3 and 4, two ULN2803s drive the stepper motors.

well. Another possibility is glass fiber-epoxy rods cemented with epoxy. Triangular webbing will help to reinforce the joint.

The sleeve bearings can be made from sections of plastic tubing. These can be cemented to wooden stand-off blocks glued or attached by screws to the board. Alternatively, holes can be drilled in taller wood standoff blocks and plastic sleeves, such as sections of large-diameter soda straws can be inserted as bearings.

Notice that the tee frames are mounted so that they lie in planes parallel to the surface of the plotting board. The height of the sleeve bearings above the plotting board will depend on the available clearance distance between the X and Y stepper motor shafts and the plotting board. A vertical separation of at least ¼-inch between frames is recommended to prevent mechanical interference throughout the frame's complete range of motion.

The part with the two bearings and attached tool holder can be made by cementing together three plastic tubes as shown in Fig. 2. The tool holder, which could be made of plastic or aluminum, should have an inside diameter large enough to accommodate a thin, light, felt-tipped pen. A set screw in the sidewall of the holder could clamp the pen or tool, but a folded leaf spring or wedge would also work.

Assemble all the mechanical parts of the plotter as shown in Fig. 2, and attach and secure all the cords that move their respective mechanical elements. Then manually move the tee frames to their full extent to be sure there is no mechanical interference between parts or bearing misalignment. Make any repairs necessary to assure that all mechanical parts move smoothly without binding.

Motor drive board.

The four integrated circuits in the motor drive circuit are readily available from many electronics stores and the mail-order electronics distributors advertised in this magazine. All are alternate-sourced by at least two semiconductor manufacturers. A suitable 8-bit IBM PC-XT plug-in prototyping board for use as the circuit board is also available as a stock item from many of the same sources.

The four integrated circuits on the circuit board are a 8255A-5 programmable peripheral interface or equivalent (8255A, 8255-5, or 82C55-5) (IC1), a 74LS138 1-of-8 decoder/demultiplexer for address decoding or CMOS equivalent (IC2), and two ULN2803 high-voltage, high-current Darlington arrays (IC3 and IC4).

The 8255A has 24 output pins but only twelve are used in this project—four for each stepper motor. All eight channels of one ULN2803 (IC1) are used to drive the coils of the X-axis and Y-axis stepper motors. Each coil of the stepper sinks 500 milliamperes when it is turned on by the digital logic.

The ULN2803 consists of eight parallel driver channels, each with load current ratings to 500 milliamperes. Each channel consists of a Darlington buffer/inverter and a flyback diode suitable for interfacing between low-level logic and a peripheral power load such as a stepper motor coil. The software turns on only one coil at a time. The ULN2803 is an inverter, so when the 8255 line goes low, the stepper is switched on; when the line goes high, the coil current falls to zero.

Figure 4 is a suggested parts placement diagram for the circuit board. Component placement on this card is not critical, but lead lengths should be kept to a minmimum. Sockets are recommended for all ICs. Integrated circuits IC1 and IC2 can be either bipolar TTL or CMOS that is particularly sensitive to damage from electrostatic discharge (ESD). However, observe proper handling precautions when handling either kind.

Notice that the components are located on the side of the

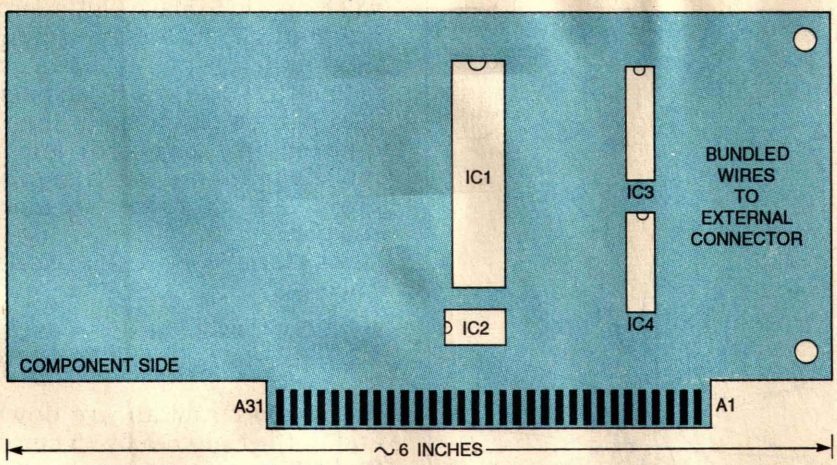


FIG. 4—CIRCUIT BOARD IS AN IBM-XT compatible 8-bit prototype plug-in card. Component placement is not critical, but wiring should be kept as short as possible. The component side is shown.

board with the A1 to A31 terminal "fingers." The board is inserted in the computer card-edge connecter with the drilled holes on the right side of the board, as shown in Fig. 4, closest to the back of the computer. The B1 to B31 terminations are on the solder side of the board.

The wires from output pins 11 to 18 on IC3 and 15 to 18 on IC4 connect the drivers to the three stepper motors as shown in the schematic, Fig. 3. An additional wire connects the 12-volt source from B9 to the common +12-volt wires on the stepper motors. All wires should be cut at least 12 inches long so they can be soldered to the IC pins and +12-volt terminal and clamped securely to the circuit board.

Drill a ¼-inch hole in the "L" bracket that is bolted to the end of the circuit board for covering the slot in the computer card cage. Insert a protective rubber grommet in the hole, bundle the 12 drive wires and +12-volt wire, and insert them through the grommet. It is recommended that all 13 wires be terminated with a circular connector socket having at least 15 contacts.

The five wires (four coil wires and +12-volt wire) from each motor can be cut to a length of about four feet. They should be bundled or inserted in a vinyl protective sleeve and terminated in a mating connector plug. The three +12-volt wires can be jumpered together within the plug so that they mate with the +12-volt wire in the socket. This arrangement permits the X-Y plotter to be disconnected and stored conveniently when not in use.

Drive software

The software written for this plotter will give the builder ample opportunities for programming. The objective of the program is to apply pulses to the stepper motor coils so that the drive shafts respond as directed. Sample software source code is available as file PLOTTER.C on the *Electronics Now* bulletin board 516-293-2283, V.32, V.42bis).

Programming

The card can be set up for eight different beginning port addresses depending on the chip select (CS) pin from IC2 74LS138 selected:

PIN	ADDRESS (HEX)	ADDRESS (DECIMAL)
15	200	512
14	220	544
13	240	576
12	260	608
11	280	640
10	2A0	672
9	2C0	704
7	2E0	736

If you connect the CS line to pin 9, then the beginning port address will be 704 (hex 2C0). The 8255A-5 IC has four ports. Port A is at address Ø, port B is at address + 1, port C is at address + 2 and the configuration port is at address + 3. The common configuration for the port is all outputs (control word 128 (hex 80)). The 8255A-5 can be configured for inputs as well as outputs. (For example, control word 133 (hex 85) converts ports A and B to outputs and port C as inputs if sensors were used).

To make the motors step sequentially, pulse each binary line: 1, 2, 4, 8. For the high-order nibble pulse: 16, 32, 64, 128. Be sure the delay is long enough for the pulse to drive the motor through the next step. If all the circuitry is correct and the motor shaft does not rotate, the delay is probably too short.

Programming example

The first step is to send the configuration data to the integrated circuit. That can be done with the BASIC statement:

```
10 OUT 707,128
```

Next, the stepper motor is sequenced and a delay is added between each step:

```
20 FOR I=0 TO 100
30 OUT 704,1
40 FOR DELAY=0 TO 100:
   NEXT DELAY
50 OUT 704,2
60 FOR DELAY=0 to 100:NEXT
   DELAY
70 OUT 704,4
80 FOR DELAY=0 to 100:NEXT
   DELAY
90 OUT 704,8
100 FOR DELAY=0 to 100:
   NEXT DELAY
110 NEXT I
```

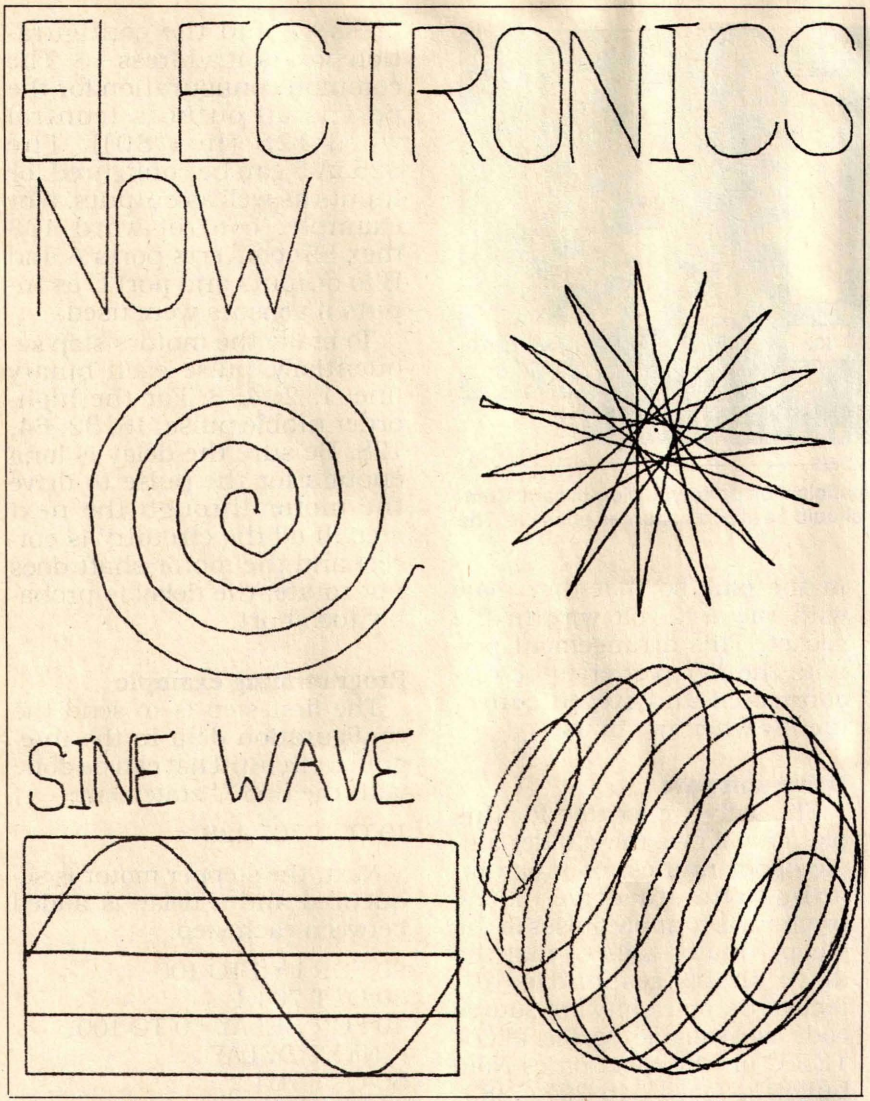
Then turn off the motor:

```
120 OUT 704,0
```

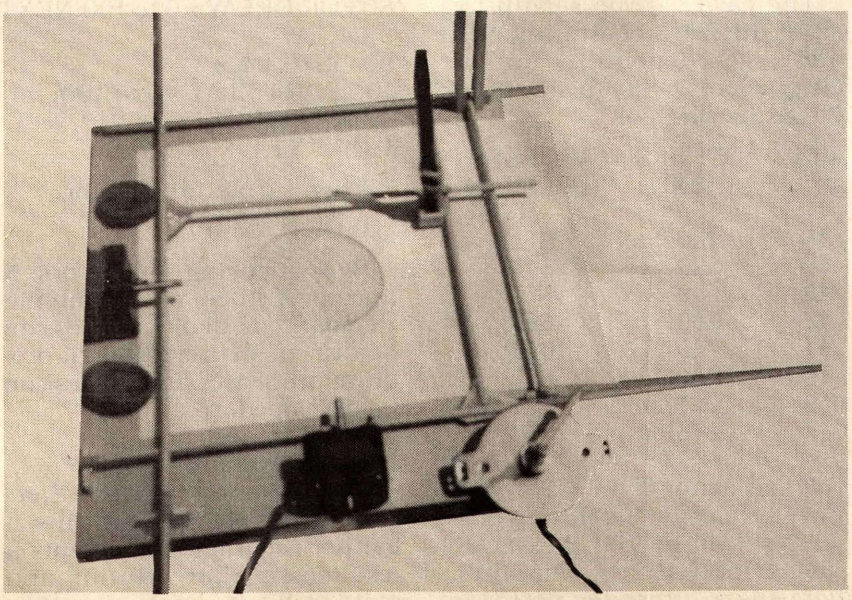
By sequencing the motors, X lines or Y lines, or a combination of them, diagonal lines can be drawn. With additional programming, arcs and circles can be developed.

Banner program

The file posted on the *Electronics Now BBS* contains a banner program that accepts a text message for printing and plots each letter of the message. The sample program given here



HERE ARE SEVERAL EXAMPLES OF output from the author's prototype plotter, shown below.



AUTHOR'S PROTOTYPE PLOTTER, although simple in construction, was able to produce impressive results.

will help you to learn plotter programming. It defines each of the 26 capital letters. All letters are defined by 10 pulses. Each pulse step can be either be a line, a quarter arc, a pen lift and a move command. Each step is given X and Y directions to move the pen.

For example, the letter B is defined by:

1,0,60, Draw a line 60 steps up.
1,15,0, Draw a line to the right 15 steps.
2,15,-15, Draw an arc down and to the right, 15 by 15 steps.
2,-15,-15, Draw an arc down and to the left, 15 by 15 steps.
1,-15,0, Draw a line to the left 15 steps.
1,15,0, Draw a line to the right 15 steps.
2,15,-15, Draw an arc down and to the right, 15 by 15 steps.
2,-15,15, Draw an arc down to the left 15 by 15 steps.
1,-15,0, Draw a line to the left 15 steps.
3,35,0, Move to the right 35 steps for the next letter.

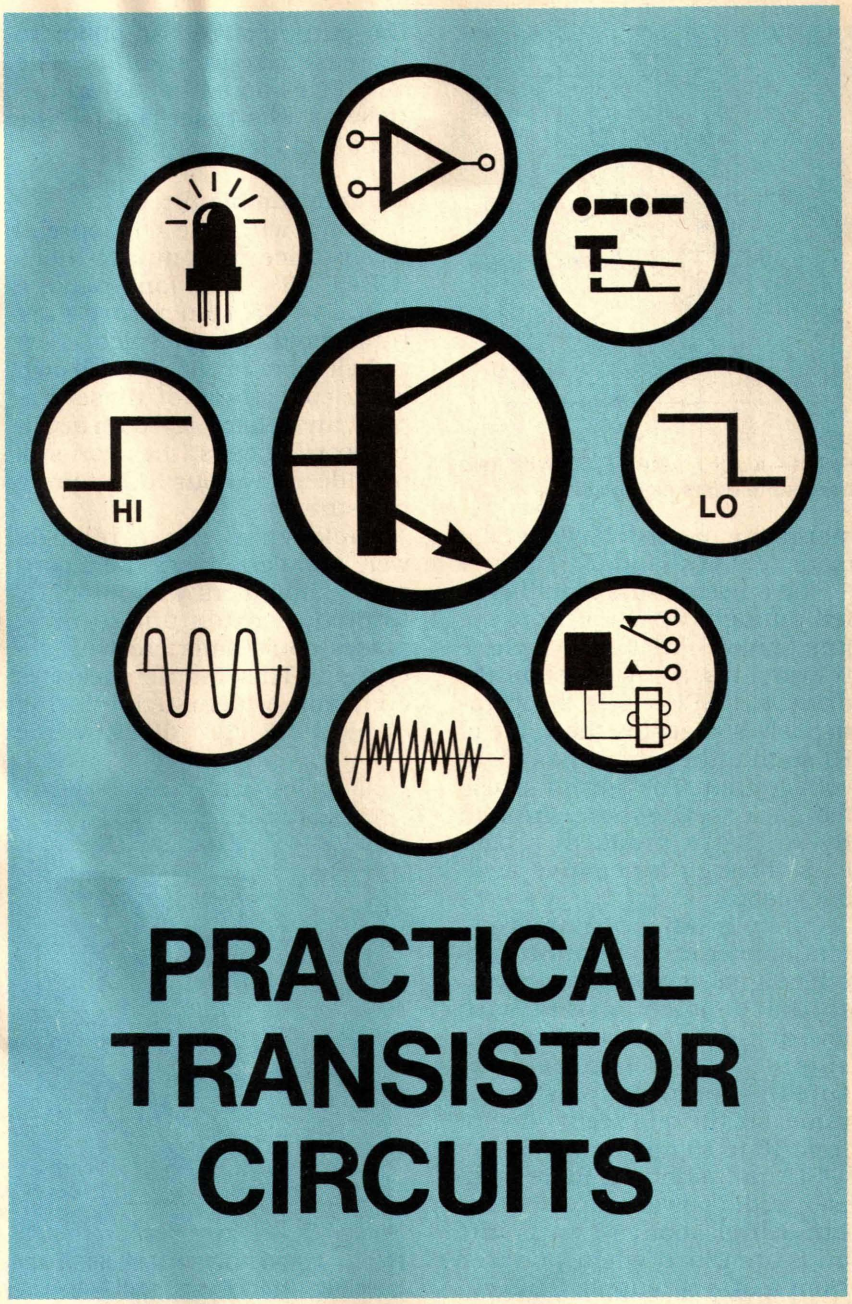
The main loop looks up each character in the message and moves the pen the number of steps defined for each character until all of the characters are drawn.

The line and arc subroutines listed will move the pen in the direction desired. To enlarge the characters, increase the scale factor. This will multiply the number of steps required to draw each line.

The delay subroutine allows the stepper motor to dwell long enough for the voltage to reach the value that will step the motor. *Note*: This program was developed on an IBM personal computer with an Intel 80286 microprocessor. Adjustments in delay-time might have to be made for reliable motor stepping if the programming is done on a different computer.

Other computers might speed up the plotter by decreasing the delay time until movement becomes unreliable. If this occurs, additional time can be added to increase motor reliability. With the subroutines included here and innovative programming, almost any kind of line artwork can be drawn. Ω

RAY MARSTON



PRACTICAL TRANSISTOR CIRCUITS

Build these circuits that can amplify, filter, generate white noise, flash lamps, locate hidden metal—and perhaps even detect lies.

THIS LAST ARTICLE ON BIPOLAR junction transistors (BJT) is a potpourri of circuits. Some are practical and some are not so practical, but they can be great fun for experiments. With these circuits you can amplify signals, filter high and low frequencies, generate white noise, and flash lamps. You can also boost DC voltage levels, locate hidden metal objects, and detect rising water. One circuit will even demonstrate the fundamentals of lie detection!

Last month's article concentrated on the operating principles and design options for audio power amplifiers. Earlier topics in this series have included descriptions and schematics for low-power amplifiers, preamplifiers, tone-control circuits, multivibrators, and various oscillators.

More power amplifiers

Today the easiest way to build a low- to medium-power audio amplifier is to pick an integrated circuit amplifier from a manufacturer's data book and supplement it with additional components recommended in the applications notes in the data book. However, if you just want to learn amplifier principles by experimentation or you have a simple application in mind, you should build the amplifier with discrete transistors.

Figure 1 is a schematic for a general-purpose, low-power, high-gain amplifier based on discrete transistors. A Class A amplifier, it can drive a load such as a speaker or headset with an impedance greater than 65 ohms. The amplifier draws a quiescent current of about 20 milliamperes. However, this drain can be reduced by increasing the value of R3.

Transistors Q1 and Q2 are configured as common-emitter amplifiers; the output of Q1 is directly coupled to the input of Q2. This circuit has an overall voltage gain of about 80 dB. Notice that resistor R3, the emitter load of Q2, is decoupled by capacitor C3 so that the Q2 emitter *follows* the average collector voltage of Q1.

The base bias for Q1 is derived from Q2's emitter through R2. With this configuration, the bias is stabilized by negative DC feedback. Input potentiometer R4 serves as the circuit's volume control.

Figure 2 is the schematic for a simple, three-transistor, Class AB complementary amplifier which can drive about 1 Watt into a 3-ohm speaker load. Transistor Q1, which is configured as a common-emitter amplifier, drives a load that is the sum of speaker SPKR1, resistor R1 and potentiometer R5. Its output voltage is *followed* and boosted in power by the comple-

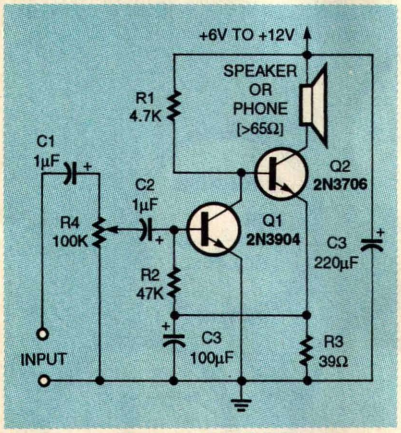


FIG. 1—AUDIO AMPLIFIER with two transistors offers high gain.

mentary emitter-follower stage made up of Q2 and Q3.

The output of the amplifier is fed through capacitor C2 to the junction of SPKR1 and R1 where it provides a low-impedance drive for SPKR1. It simultaneously bootstraps the value of R1 so that the circuit has high-voltage gain. The output is also fed back to Q1's base through R4 so that it produces a base bias through a negative feedback loop.

Carefully adjust trimmer potentiometer R5 to minimize audible signal crossover distortion so that it is consistent with lowest quiescent current consumption that can be measured. To obtain a reasonable value, set the quiescent current from 10 to 15 milliamperes.

Figure 3 shows a more complex audio power amplifier that can deliver about 10 watts into an 8-ohm load when powered from a 30-volt supply. This circuit includes four, high-gain, quasi-complementary output stages (Q3 to Q6). Transistor Q1 functions as an adjustable *amplified diode* output biasing device in this circuit.

The main load resistor R2 of the Q2 common-emitter amplifier stage is bootstrapped by C2 and DC biased by R3. This network should set the quiescent output voltage at about half the power supply value. If it does not, alter the value of R3. The upper frequency response of the amplifier is restricted by C3, which enhances circuit stability. In addition, capacitor C5 is wired in series with R8 across the output of the amplifier to increase circuit stability. The amplifier should be set up initially as was described for the circuit in Fig. 2.

Scratch/rumble filters.

Today, with the widespread acceptance of compact discs (CDs), 33⅓ rpm long-playing (LP) and 45 rpm records are considered to be obsolete. Nevertheless, many people still own large collections of these records, and when played on quality record players, they can still provide many hours of listening pleasure.

Back when those records were popular, unless the record player amplifiers were properly filtered, scratch and rumble noises could interfere with reception. This interference was even more evident in the playing of older 78 rpm discs. While scratch and rumble are no longer universal problems, the techniques for eliminating them are still interesting.

Scratch noise is essentially sound at a frequency greater than 10 kHz picked up from the disc's surface, while *rumble* is sound at a frequency typically less than 50 Hz caused by variations in turntable drive motor speed. Each of these noises can be effectively eliminated or attenuated by passing the audio output from the record player through a filter that rejects the annoying parts of the audio spectrum.

The rumble filter in Fig. 4 is a high-pass filter that provides unity voltage gain for all frequencies greater than 50 Hz. However, it provides 12 dB per octave rejection to all frequencies below 50 Hz. For example, attenuation is 40 dB at 5 Hz. Transistor Q1 is configured as an emitter-follower biased at about half the supply value from the low-impedance junction formed by resistors R1 and R2 in parallel with capacitor C3.

However, negative feedback applied through the filter network of R3, C2, C1, and R4 causes an *active* filter response. The rolloff frequency of the circuit can be altered, if desired, by changing the values of capacitors C1 and C2—provided that they are kept equal. For example, if the values of C1 and C2 are reduced 50% from 0.220 to 0.110 microfarads, the rolloff frequency will be doubled to 100 Hz.

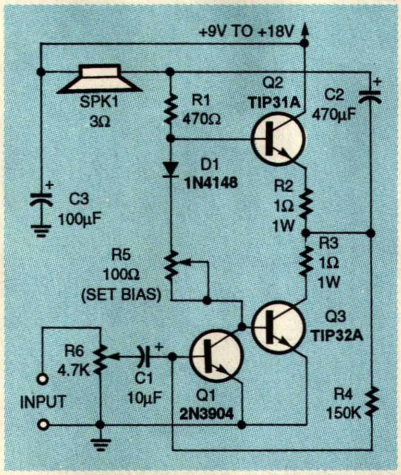


FIG. 2—AUDIO POWER AMPLIFIER with three transistors has a 1-watt output.

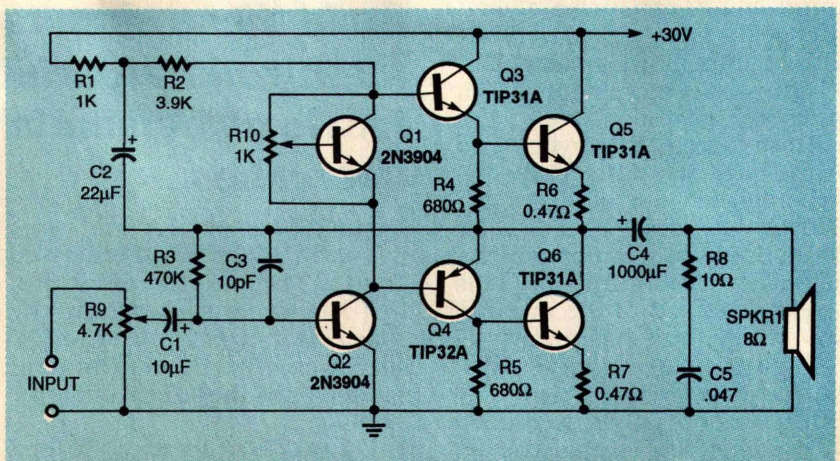


FIG. 3—AUDIO POWER AMPLIFIER WITH SIX TRANSISTORS has a 10-watt output.

The scratch filter circuit of Fig. 5 acts as a low-pass filter that provides unity voltage gain to all frequencies below 10 kHz, but it rejects all frequencies above 10 kHz at 12 dB per octave. This circuit resembles Fig. 4 except that the positions of the resistors and capacitors are transposed in the network consisting of C2, R4, C4, and R5.

The rolloff frequency of that circuit can be altered, if desired, by changing the values of C2 and C4. For example, if both are increased from 0.0022 to 0.0033 microfarads, the rolloff frequency is reduced from 10 kHz to 7.5 kHz.

The circuits of Figs. 4 and 5 can be combined to make a composite scratch and rumble filter. The output of the high-pass filter is connected to the input of the low-pass filter. If desired, bypass switches can be installed in the individual filter sections so that the filters can easily be switched in and out of circuit. This change is illustrated schematically in Fig. 6.

It's worth noting that if the circuits of Figs. 4 and 5 are built on a single board, three components can be saved by making the biasing network composed of resistors R1 and R2 and capacitor C3 common to both filter circuits.

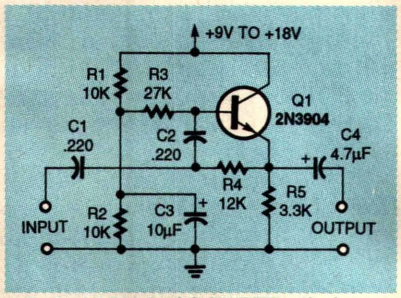


FIG. 4—HIGH-PASS FILTER eliminates 50-Hz record player "rumble".

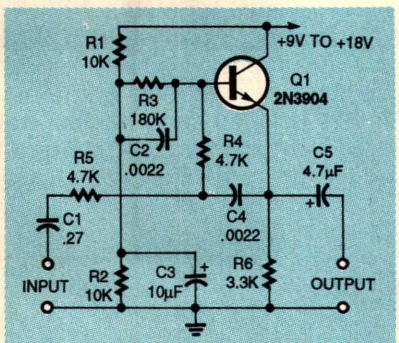


FIG. 5—LOW-PASS FILTER eliminates 10-kHz record player scratch noise.

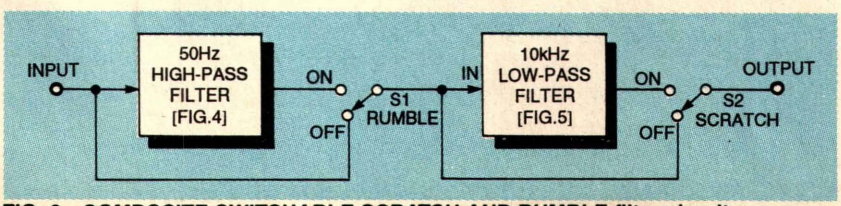


FIG. 6—COMPOSITE SWITCHABLE SCRATCH AND RUMBLE filter circuit.

Noise circuits

White noise is a steady hissing sound obtained by mixing a full spectrum of randomly generated audio frequencies, each having equal sound power when averaged over time. White noise can be heard by tuning an FM radio receiver to that part of the band where no nearby stations can be heard. It is intentionally generated for testing audio- and radio-frequency amplifiers. It can also be an effective sleep aid because it masks random background noises from voices, passing vehicles, car horns, closing doors, and other sources.

Figure 7-*a* is the schematic for a simple but useful white noise generator based on the inherent white-noise generation capability of a reverse-biased Zener diode. In this circuit, resistor R2 and Zener diode D1 form a negative-feedback loop between the collector and base of common-emitter amplifier Q1.

This loop stabilizes the DC working levels of the circuit, and capacitor C1 decouples the AC. As a result, D1 becomes a white-noise source in series with the base of the Q1, which amplifies that noise to a useful level of about 1 volt, peak-to-peak.

The base-emitter junction of any silicon transistor can function as a noise-generating Zener diode if its junction is reverse-biased to its breakdown level. This breakdown typically occurs in a 2N3904 small-signal BJT at about 6 volts. Figure 7-*b* shows the schematic of a two-transistor, white-noise generator. In this circuit Q1 acts as a Zener diode.

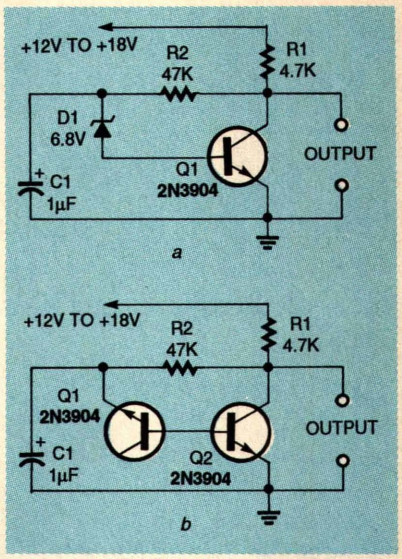


FIG. 7—WHITE NOISE GENERATORS with a transistor and Zener diode (*a*), and one with two transistors (*b*).

Audio noise can be annoying, especially if you are trying to listen to a very weak broadcast station. You might find that the peaks of unwanted background noise completely swamp the broadcast signal, making it unintelligible. It is possible to overcome this problem with the *noise limiter* circuit shown in Fig. 8.

In this circuit, both the signal and the noise are fed to amplifier Q1 through potentiometer R3. Transistor Q1 amplifies both waveforms equally, but diodes D1 and D2 automatically limit the peak-to-peak output swing of Q1 to about 1.2 volts. If R3 is adjusted so that the signal output is amplified to this peak level, the noise peaks will not exceed signal output. Therefore, the received signal will be far more intelligible.

Astable multivibrators

The *astable multivibrator* or *square-wave generator* circuit is versatile. Figure 9, for example, shows how it can flash two light-emitting diodes (LED) about once per second. Its flash rate is controlled by the time-

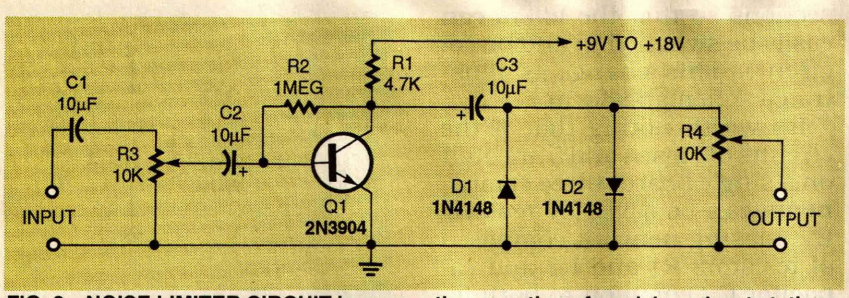


FIG. 8—NOISE LIMITER CIRCUIT improves the reception of weak broadcast stations.

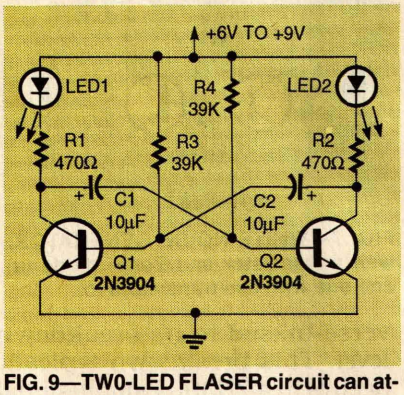


FIG. 9—TWO-LED FLASER circuit can attract attention.

constant values of resistive-capacitive combinations of R4 and C1 and R3 and C2.

The LEDs are in series with the collectors of transistors Q1 and Q2, and they flash on and off symmetrically out-of-phase with each other. The flash rate can be changed by altering the values of either R4 and C1 or R3 and C2. You can also replace one of the LEDs with a short circuit to make the circuit a one-LED flasher.

Figure 10 is a simple variation of the Fig. 9 astable multivibrator. This circuit generates an asymmetrical waveform at about 800 Hz, which is fed to speaker SPKR1 and limiting resistor R_X in the collector circuit of Q2. A monotone audio signal is generated when switch S1 is closed.

This circuit becomes a simple sound generator if S1 is a simple on-off switch, or it can be a Morse-code practice oscillator if a telegrapher's key is substituted for S1. The frequency of the generated tone can be changed by altering the values of either or both capacitors C1 and C2.

Figure 11 shows how an astable multivibrator can act as a signal injector-tracer for testing radio receivers. When S1 is in the INJECT position 1, transistors Q1 and Q2 are configured as a 1-kHz astable multivibrator. With that setting, a sharp squarewave signal is sent to the PROBE terminal through R1 and C1.

That waveform, which is rich in harmonics, will produce an audible output through a radio's loudspeaker if it is injected into any audio- or radio-frequency stage of an amplitude-modulated radio. By selecting a suitable injection point, the injector can help in troubleshooting a defective radio.

When S1 is switched to TRACE position 2, the circuit is configured as a cascaded pair of common-emitter amplifiers. The PROBE input feeds the base of Q1 and Q2's output driving headphone Z1. Consequently, any weak audio signal fed to the PROBE will be amplified directly and heard in the headphone.

Similarly, any amplitude-modulated radio-frequency signals that are fed to the PROBE will be demodulated by the nonlinear response of transistor Q1, and the resulting audio signal will be amplified and heard in the earphone. If the PROBE is connected at suitable test points in a radio, the tracer can troubleshoot faults.

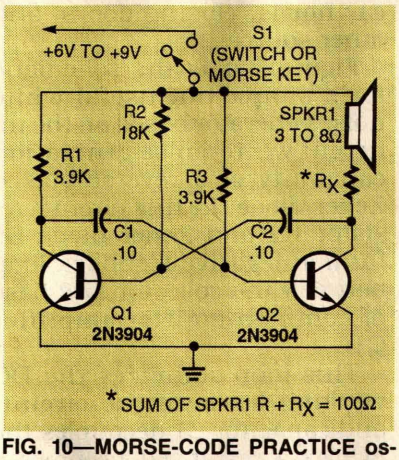


FIG. 10—MORSE-CODE PRACTICE oscillator is a multivibrator with a telegrapher's key.

LC oscillators.

Many applications can be found for inductance-capacitance (LC) oscillators in test equipment and practical circuits. Figure 12 is a *local oscillator* or *beat-frequency oscillator (BFO)*. Transistor Q1 is configured as a conventional Hartley oscillator with a modified 465 kHz intermediate frequency transformer as its collector load.

If the internal tuning capacitor of the transformer is removed, variable capacitor C1 becomes the tuning control of a variable-frequency oscillator. The output frequency can be varied from well below 465 kHz to well above 1.7 MHz.

Any radio capable of receiving broadcast band frequencies will detect the oscillation frequency if it is placed near the signal generator circuit. If the signal generator is tuned to the inter-

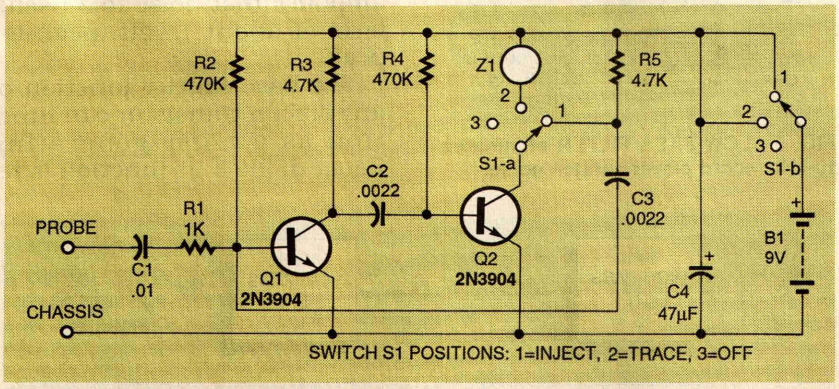


FIG. 11—AUDIO-RADIO SIGNAL INJECTOR and tracer will help in troubleshooting ailing radios.

mediate frequency of a radio, a beat note can be heard. This will permit continuous-wave or single-sideband transmissions to be detected.

Figure 13 is a modification of Fig. 12 without a transformer secondary. When the circuit is functioning with a nearby radio receiver acting as a detector and amplifier, it becomes a simple metal object locator. Oscillator coil L1 is made by winding 30 turns of wire tightly on a 3- to 4-inch diameter plastic core or bobbin about 1 inch long. It becomes a *search head* or *sensing coil* when it is connected to the circuit with a 3-wire cable.

The search head or sensor can be mounted at the end of a long wooden or plastic handle if you want to use the circuit as a classic ground-sweeping metal detector. Similar circuits can detect buried treasure or military mines that include at least some metal parts. However, the complete circuit can be housed in a handheld case if you want to locate metal pipes or wiring that are hidden behind walls that are made of brick, wood, or plasterboard.

The operation of the object locator circuit in Fig. 13 depends on the presence of a metal object that will interfere with coil L1's electromagnetic field. The interfering object changes both the inductance value of L1 and the frequency of the field. The presence of the metal object can be detected by a battery-portable broadcast band radio held close to the locator circuit. It senses the frequency shift and gives out an audible screech.

To detect a hidden metal object, first tune the radio to a local station, and then adjust C1 so that a low-frequency *beat* or chirp is heard from the radio's speaker. This beat note will change significantly if the locator circuit is placed near the hidden metal object.

Figure 14 shows the Hartley oscillator used as a DC-to-DC converter. It is capable of converting the output of a 9- volt battery to 300-volts DC. Transformer T1 is a 9-0-−9-volt to 250-volt transformer. Its primary forms the inductance (L) part of the oscillator.

The supply voltage is stepped up to a peak of about 350 volts at T1's secondary. This waveform is rectified by half-wave rectifier diode D1, and it charges capacitor C4. With a permanent load, the output falls to about 300 volts at a load current of a few milliamperes. *Caution:* Without a permanent load across C4, the capacitor can deliver a powerful but nonlethal shock to the unwary.

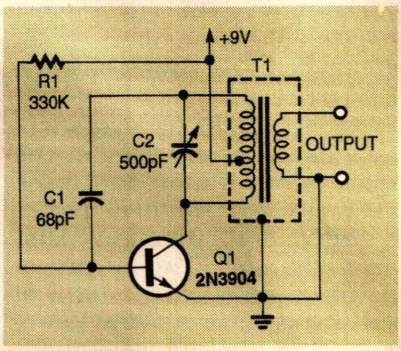


FIG. 12—BROADCAST BAND SIGNAL generator/ beat-frequency oscillator.

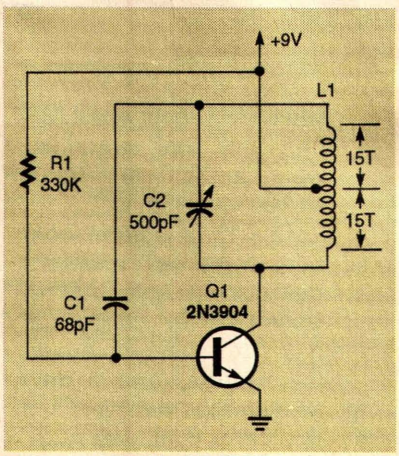


FIG. 13—METAL OBJECT locator can hunt for hidden metal pipes or wires.

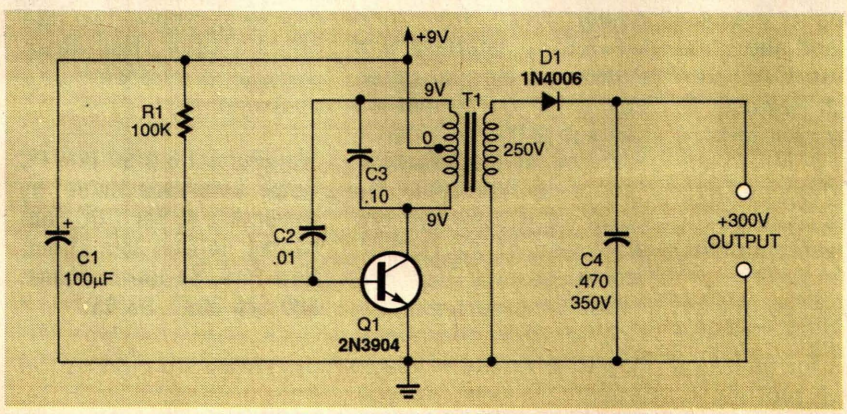


FIG. 14—DC-to-DC CONVERTER CIRCUIT BOOSTS 9 volts to 300 volts.

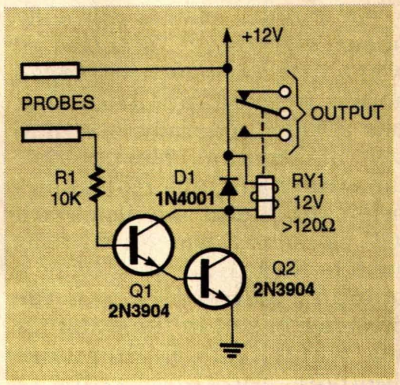


FIG. 15—RELAY CIRCUIT IS activated when probes are immersed in water.

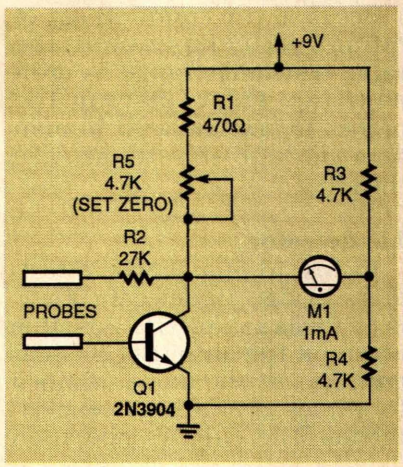


FIG. 16—SIMPLE "LIE DETECTOR" circuit is suitable for experiments and fun.

Conductive water switch

A relay switch in a circuit that can be activated when a pair of probes come in contact with water can be very useful around the home or on a boat. It might, for example, indicate flooding of a basement, or water in the bilges of a boat. Figure 15 is a conductive-water-operated relay. Transistors Q1 and Q2 are a Darlington pair configured as a common-emitter, and relay coil RY1 is the collector load.

The circuit relay is normally open (NO), but it is activated when the probes are placed across a resistance path that has a value generally less than several megohms. Most potable tap water has a bulk resistances below this value, so this circuit will work as a water-level relay switch. Relay RY1 can activate a pump or alarm. However, the presence of salt in the water (or sea water) has higher conductivity, and it can enhance the effectiveness of the detection circuit.

Because the conductivity of human skin has about the same resistance range as ordinary tap water, placing the probes in contact with human skin can also serve to activate the relay.

Lie detector

Figure 16 is a simple Wheatstone bridge "lie detector." However, because of the possible errors in the output of this circuit, its use should be confined to games or informal experiments. The circuit's operation is based on the knowledge that the resistance of human skin changes as a result of changes in the emotional state of the subject.

The bridge of this detector circuit is formed by resistor R1 and potentiometer R5 in one arm, R3 in a second arm, R4 in a third arm, and transistor Q1 (with a probe in its base circuit) in the fourth arm.

A milliammeter with its zero point at the center of the scale is connected across the bridge. It serves as a bridge-imbalance detector. Resistor R2 in series with the second probe is attached to the junction between Q1's collector and the low side of potentiometer R5. Large bare copper bars or silver spoons can be used to make suitable probes.

The probes should be taped or strapped directly to the skin on the subject's hand or arm, separated by at least several inches. When the subject is relaxed and his or her skin resistance reaches a stable value, adjust potentiometer R5 to obtain a null on milliammeter M1. The subject can then be questioned about the truth or falsity of emotionally loaded or embarrassing subject—in fun, of course.

The subject's skin resistance will change in response to questions of that kind if they are phrased correctly. The bridge should be unbalanced if the subject reacts emotionally to the questions. Experiments of this kind are often performed by students taking college-level experimental psychology lab courses, but the equipment that they use is usually more sophisticated and sensitive than this circuit.

Professional lie detectors typically factor in changes in the subject's respiration and pulse rate measured by other sensors to supplement the skin-resistance changes. The output of the machine is in the form of pen traces on a moving paper strip. Nevertheless, you might be surprised with the results you get experimenting with this simple circuit. Ω

NEW LITERATURE

continued from page 29

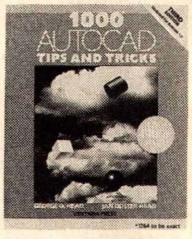
ate, audio, video, and radio frequencies. You will also find linear and switching power supplies, digital, and optoelectronic circuits. Moreover, amplifiers, regulators, oscillators, and signal waveform generators are covered. And you'll find information on voltage-to-frequency, analog-to-digital and digital-to-analog conversion, temperature sensing, and machine control.

All the circuits are grouped by function, and a specific troubleshooting approach is outlined for each circuit category. The book also lists proven component values the circuits, and includes suppliers of those components and their mailing addresses.

1000 AutoCAD Tips and Tricks: Third Edition; by George O. Head and Jan Doster Head. Ventana Press, P. O. Box 2468, Chapel Hill, NC 27515; Phone: 919-942-0220; Fax: 919-942-1140; $27.95.

This tips and tricks book is based on the authors' years of accumulated trial and error experience in working with AutoCAD. The book is organized into a compendium of practical techniques and shortcuts covering AutoCAD versions through Release 12. Arranged by skill level in "Beginning," "Intermediate," and "Advanced" sections, it offers useful advice on all the newest AutoCAD features.

For example, you'll learn how to use state-of-the-art dialog boxes for functions ranging from plotting to programming and how to



CIRCLE 329 ON FREE INFORMATION CARD

manipulate new drafting tools such as grips and instant "hot" keys. The text explains how to pass information directly from AutoCAD to a database with Automatic Sequel Extension, and how to take advantage of the user-friendly features of the Windows version of AutoCAD. The book illustrates the creative use of AutoShade renderings and PostScript images inside the AutoCAD drawing and outputting to a variety of reader formats. Drawing and editing tips are included, and you'll learn about AutoLISP programs that speed up work, and 3D shortcuts and enhancements.

This third edition contains three new chapters that discuss AutoCAD release 12. They include hundreds of never-before published tips, and a new section filled with hints and tips for working with AutoCAD Windows. Purchasers of the book are eligible to receive two free newsletters that keep users informed on Autodesk updates.

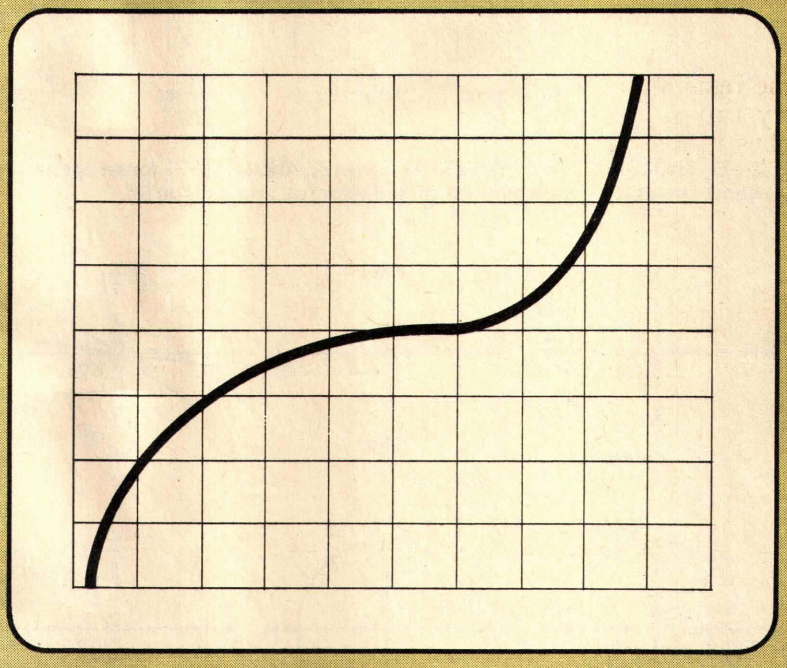
WordPerfect 6.0 for IBM PC Quick Reference Guide; by Deborah J. Miller. DDC Publishing, 14 East 38th Street, New York, NY 10016; Phone: 800-528-3897; $8.95.

This spiral-bound, pocket-size reference book on WordPerfect 6.0 is

Continued on page 74

GREGG A. CAMPBELL

ANALOG SIGNATURE TROUBLESHOOTING



Learn to troubleshoot components and circuits with a voltage source, oscilloscope, and "signatures" that provide "pass-fail" information.

ANALOG SIGNAL ANALYSIS IS A useful troubleshooting "tool" that permits you to find faulty components in unpowered circuits. The method has been known for years, but with the introduction of specialized test instruments, its use has declined. Nevertheless, it is still a valid method, and it might prove to be better than more conventional alternatives in troubleshooting situations.

To perform analog signal analysis you will need a voltage source with a standard resistor and an oscilloscope. This test method can prove effective in situations where more specialized test equipment is unavailable or inconvenient to use. Under certain circumstances, it might even save you the time taken to replace suspected parts, and it could save you the cost of buying specialized test instruments that you seldom use.

This article explains how to build a simple test fixture consisting of an AC voltage source and a standard resistor for performing the test method. To get started, you will want to determine the oscilloscope, pattern "signatures" or voltage vs. current plots obtained from a wide variety of satisfactory passive and active components to serve as references.

If you apply a voltage source across a resistor, capacitor, transformer, diode, transistor, or other component known to be good, you will obtain a distinctive oscilloscope pattern. If the components are faulty, the oscilloscope patterns obtained will differ from those taken from known good parts, indicating a fault. It is also possible to discriminate between a weak and a failed component.

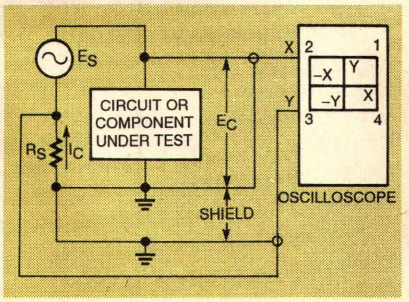


FIG. 1—AN ANALOG SIGNAL-ANALYSIS SETUP contains a voltage source (E_S) and a current-sense resistor (R_S) in series with the component or circuit under test.

Refer to the analog signal analysis test setup shown in Fig. 1. It contains an alternating current voltage source (E_S) and a current-sensing resistor (R_S) in series with the component or circuit under test. The current through R_S must be equal to the current through the component under test (I_C).

If I_C increases or decreases, the voltage across R_S can be sampled and applied to the Y-axis input of an oscilloscope to deflect the beam vertically. This deflection is directly related to the current flow in the component or circuit under test. To obtain horizontal deflection, sample the voltage drop across the circuit under test (E_C) and apply it to the X-axis input of the oscilloscope.

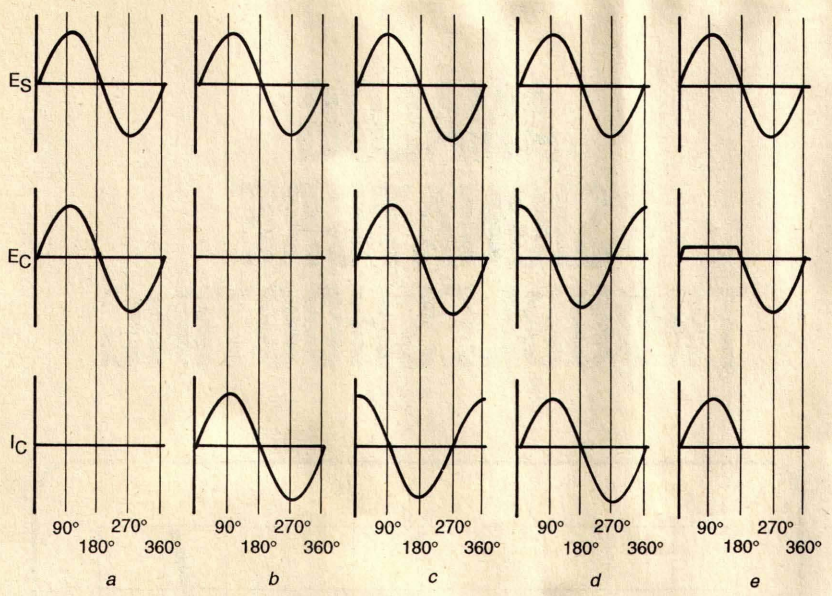


FIG. 2—E_C AND I_C PLOTTED AGAINST THE PHASE ANGLE OF E_S for an open circuit (*a*), a short circuit (*b*), a capacitor (*c*), an inductor (*d*), and a diode (*e*).

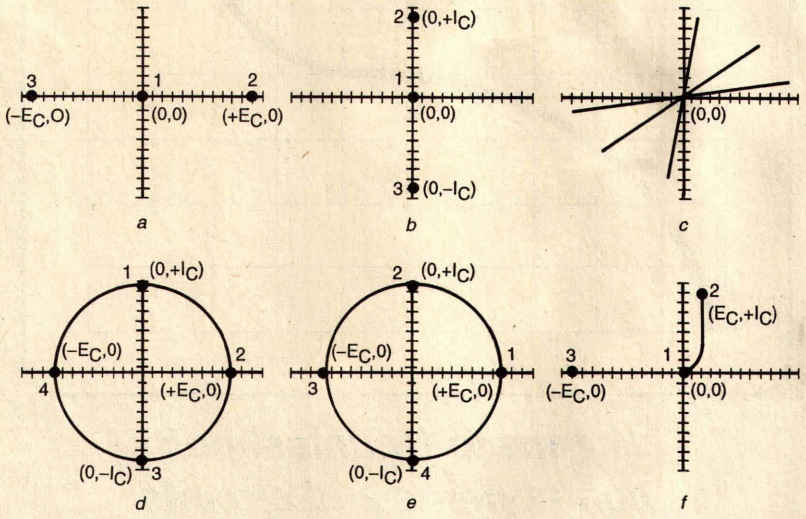


FIG. 3—THESE CARTESIAN COORDINATE GRAPHS provide accurate representations of the signatures of each component. The signature of an open circuit is a horizontal line (*a*), a short circuit is a vertical line (*b*), a resistor is a diagonal line (*c*), both capacitor and inductor show a circle (*d* and *e*, respectively), and a diode is a dog, leg-shaped trace (*f*).

Preliminary analog signatures taken on sample components and circuits will provide the necessary reference information to make analog "signatures" useful. If E_C is applied to the X input to determine X-axis deviation, and the equivalent of I_C is applied to the Y input to determine the Y-axis deviation, this will give coordinates in the form of E_C vs. I_C

After testing typical components you will be able to compile a collection of "signatures" or oscilloscpe patterns of voltage vs. current for future reference.

Analog signal analysis is not a new method. Although it was well known to many engineers and technicians years ago, it fell into disfavor with the introduction of many new and sophisticated test instruments. This is unfortunate because, in addition to eliminating the need for specialized testers in places where they might not be readily available, it will permit you to analyze circuits in situations where it is advisable to perform tests with the power off.

Figure 2 (*a–e*) shows the amplitudes of E_C and I_C plotted against the phase angle of E_S for various components. In Fig. 3 those values have been transferred at 0°, 90°, 180°, 270°, and 360° to Cartesian coordinate graphs to give accurate representations of the signature of each component.

The values shown for E_C and I_C in Fig. 2-*a* apply to an open circuit. With an open circuit there is no path for current flow, so I_C is equal to 0. At 0°, E_C and I_C are equal to zero, indicated as point 1 in Fig. 3-*a*. At the 90° mark, E_C is at its maximum positive value while I_C remains at zero (point 2 in 3-*a*). At 180° the plot is back at point 1, with E_C returning to zero and I_C unchanged. The 270° mark shows E_C at its maximum negative value while I_C again remains at zero, point 3 in 3-*a*. The 360° mark brings the plot back to the starting point 1. By connecting the points together as shown in 3-*a*, it can be seen that an open-circuit signature is a simple horizontal trace.

In Fig. 2-*b*, the values of E_C and I_C are shown for a short circuit. E_C is equal to 0 because $E_C = (I_C R_C)$, which is equal to $(I_C 0)$. Figure 3-*b* shows the short-circuit values of E_C and I_C plotted for the same five phase angles used in the first example. Connecting the points together shows a vertical line centered on the Y axis, which is the signature of a short circuit.

Figures 3-*a* and -*b* can be considered to be the signatures for two resistors. The first of these resistors would have infinite resistance, while the second resistor would have a value of zero ohms. If the resistance were to be decreased from infinity toward zero, the signature line would rotate counterclockwise into quadrants 1 and 3, with coordinate (0,0) being the pivot point; Figure 3-*c* is the signature of a resistor.

The signatures for an open circuit, a short circuit, and a resistor have been given. Now consider the signatures obtained from reactive components. Figure 2-*c* shows the values of E_C and I_C for a capaci-

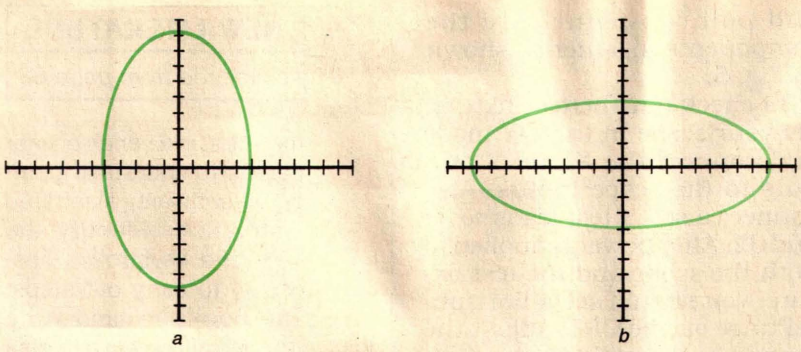


FIG. 4—IF FREQUENCY OR CAPACITANCE INCREASES, the impedance will decrease and there will be a decrease in voltage dropped across the capacitor (E_C) and an increase in current (I_C). That generates an ellipse centered on the Y axis (*a*). If either or both values decrease, the ellipse will be centered on the X axis (*b*).

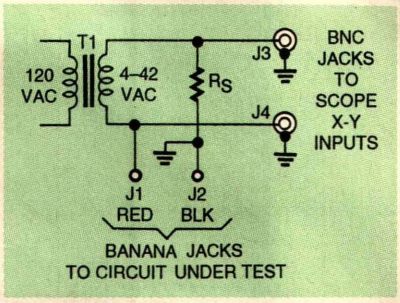


FIG. 5—TEST-FIXTURE SCHEMATIC. You must select test circuit components depending on the components that you intend to test (see text).

TABLE 1	
E_S(RMS)	I_{CMAX}
4 – 7V	135 mA
7.1 – 10.6V	9 mA
10.7 – 42V	.6 mA

tor. Notice that E_C lags I_C by 90° and has a value of zero at 0° while I_C is already at its maximum positive value; Figure 3-*d* shows this as point 1. The 90° mark of Fig. 2-*c* is indicated as point 2 in 3-*c* where E_C increases to its maximum positive value and I_C decreases to zero. Plotting the values from Fig. 2-*c* for 180°, 270°, and 360° gives points 3, 4, and back to 1 in Fig. 3-*d*. By connecting the points together you will have plotted a circle, the signature for a capacitor.

The values of E_C and I_C for an inductor are shown in Fig. 2-*d*; notice how E_C leads I_C by 90°. At 0°, E_C is already at its maximum positive value while I_C is at zero (point 1 in Fig. 3-*e*. At the 90° mark in Fig. 2-*d*, E_C is equal to zero, and I_C is at its maximum positive value. That is shown as point 2 in Fig. 3-*e*. The values shown in Fig. 2-*d* can be transferred at 180°, 270°, and 360° to complete the graph of Fig. 3-*e* giving points 3 and 4, and then returning to point 1.

Connecting those points shows that an inductor also has a circle signature. Note that the inductor's circle is developed in the opposite direction from that of a capacitor. However this opposite rotation cannot be seen when comparing the two signatures on your oscilloscope.

There are several important factors to keep in mind when working with reactive components. For instance, the CRT display will be a perfect circle only if the capacitor's impedance is equal to R_S at the test signal frequency.

For a capacitor, $X_C = \frac{1}{2}\pi fC$, where X_C is the capacitive reactance (impedance), f is the test-signal frequency, and C is the capacitance. By using that formula, it can be seen that if either frequency or capacitance increases, impedance will decrease. With a decrease in impedance, there will be a decrease in voltage dropped across the capacitor (E_C) and an increase in current (I_C). That affects the signature by generating an ellipse centered on the Y axis. If either or both values decrease, the ellipse will be centered on the X axis. This is shown in Figs. 4-*a* and 4-*b*, respectively.

The formula for inductive reactance is $X_L = 2\pi fL$, where X_L is the inductive reactance (the impedance), L is the inductance, and f is the test-signal frequency. An increase in either frequency or inductance causes an increase in impedance, which causes an increase in E_C and a decrease in I_C. The result is an ellipse centered on the X axis as shown in Fig. 4-*b*. A decrease of inductance or frequency produces a decrease in impedance, which decreases E_C and increases I_C, producing a ellipse centered on the Y axis as shown in Fig. 4-*a*.

The signatures shown so far are those generated by passive components. The next step is to develop the signature of an active component. An ordinary diode will be used as the example because, in general, active devices are composed of diode junctions.

E_C and I_C for a diode are shown in Fig. 2-*e*. Note that E_C increases in a positive direction until the diode becomes forward-biased. At that point E_C will not exceed the forward voltage drop of the diode. Simultaneously, I_C increases and con-

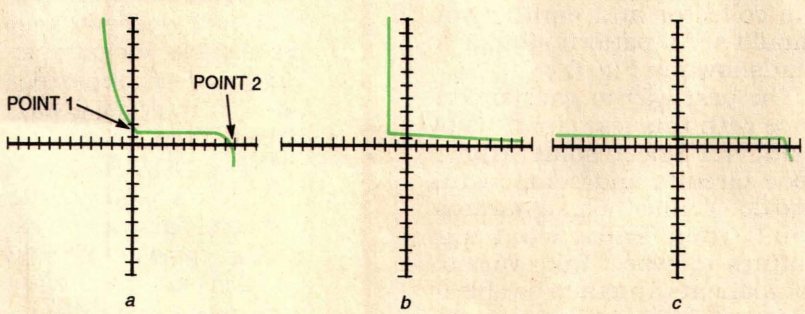


FIG. 6—WITH A SMALL-SIGNAL TRANSISTOR mounted on a breadboard and the test probes connected across the base-emitter junction, you should see a pattern similar to the trace in (*a*), where point 1 is the forward-biased diode junction and point 2 is the reverse-biased breakover of the diode junction. The base-collector junction is shown in (*b*). By connecting the test probes between the collector and emitter you should see a trace like (*c*).

tinues increasing as E_S increases. When E_S falls below the diode's forward bias voltage, E_C follows E_S, and I_C decreases to zero (see Fig. 3-*f*).

The exact value of the forward voltage drop is not critical here. When checking active components, it is important that you see a sharp junction break-over. That's where any weaknesses in semiconductor devices can be detected.

Test fixture

It's easy to build a power-source test fixture that will let you perform analog signal analysis on circuits and components. The test circuit is generic in that the selection of components depends on what you intend to test with it. Figure 5 shows the test circuit.

Most step-down transformers will work well as voltage sources. Table 1 lists voltage ranges and specifies the maximum short-circuit current. The current ratings will ensure that no active device being tested can be damaged by the test signal. All voltages and currents are in root mean square values.

To find the value for R_S, look up the transformer's output voltage in Table 1 and use the formula:

$$R_S = E_C/I_{CMAX}.$$

If that formula gives you a resistance value that's not readily available, choose the closest higher value you can find. For example, if you calculate a value of 833 ohms for R_S, a resistor of 910 or 1000 ohms will work well.

The enclosure size is determined by the size of the transformer you have chosen. After selecting an enclosure, drill holes in the front panel for mounting banana jacks J1 and J2, and in the rear for BNC jacks J3 and J4, and mount them all in place. Be sure to isolate the BNC jacks from the chassis if you use a metal enclosure.

Determine the BNC jack that is to be connected to the X-axis and the one that is to be connected to the Y-axis, and mark them at this time. Mount the transformer in the enclosure and point-to-point wire the components together as shown in Fig. 5.

To check out the test fixture, set your scope in the X-Y mode and connect the X and Y outputs to the scope inputs. Also connect a set of test leads to J1 and J2. After power is applied to both the scope and the test fixture, you should see a horizontal trace on the CRT. Adjust the scope's horizontal input amplifier and position its controls to obtain a centered trace with full-scale deflection. By short-circuiting the test leads together you should see a vertical trace. Adjust the scope's vertical input amplifier for full-scale deflection with its probes short-circuited.

Operation

Mount a small-signal transistor on a breadboard and connect the test probes across the base-emitter junction. You should see a trace similar to the one in Fig. 6-*a*, where point 1 is the forward-biased diode junction and point 2 is the reverse-biased breakover of the diode junction. The actual point of the reverse break-over will depend on the source voltage and the junction's ratings. The results in Fig. 6 are normal and do not indicate device failure.

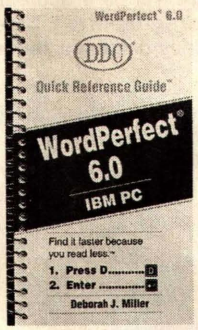
Figure 6-*b* shows the plot of a base-collector junction. Notice there is no reverse breakover here because transistors have a much higher reverse-voltage rating on their base-collector junctions than they do on their base-emitter junctions. By connecting the test probes between the collector and emitter you should see a pattern similar to that shown in Fig. 6-*c*.

The best way to gain experience with this test circuit is by using it. Select some known good circuits and components and determine their signatures. You'll then know what signatures to expect from various components and then be able to use that information to track down all kinds of circuit problems. You'll also have another troubleshooting aid to add to your collection of test methods and equipment. Ω

NEW LITERATURE

continued from page 68

the latest in a series of user guides for personal computer software. Illustrated instructions identify the keys and keystrokes necessary to carry out steps. The books minimize the wording and are in a "press this-type that-format.



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The "Find it faster because you read less" format will be of most value to the computer user who has read—or tried to read—the guidance publication included with the software and who is familiar with his computer's keyboard layout and characteristics. It offers a time-saving refresher or reminder of steps to get into and out of a procedure.

Short, clear, easy to read instructions in this Quick Reference Guide explain how to get the most out of WordPerfect and take shortcuts whenever they are possible. For most procedures, the book provides up to three different ways to carry them out.

These DDC reference books are small enough to carry around or leave next to your computer. The 56 books in the series cover a wide range of word processing and spread-sheet programs as well as guides to the operating systems for both IBM and compatible PCs and Macs. Ω

HARDWARE HACKER

RBDS services, human-powered vehicles, pinball-machine resources, understanding bus switches, and programmable interconnects.

DON LANCASTER

Here are several updates on previous columns: Fluxgate magnetometer construction information appeared in the January 1994 issue of *RF Design* on pages 24–32. All that's needed are two low-cost ferrite sleeves.

Concerning the Radio Broadcast Data Service (RBDS) information presented in March: The data format is *not* directly compatible with standard serial communications. Instead, RBDS data consists of synchronous blocks that are sent as a burst message of 64 characters. Yes, these can be read by any microcontroller but you cannot just shove the data stream through a plain old serial port.

About 150 FM stations offer RBDS at this time. Las Vegas and Chicago (the sites of the Consumer Electronics Shows) provide the widest variety of coverage.

It is time for a reminder that I have a no-charge helpline that permits me to give you a quick answer to any technical question or a suitable referral. Spending restraints limit this service to U.S. calls only. Reprints of all these columns are available via *GEnie* PSRT for about 21 cents each.

Let's look at a new development of great hacker importance...

Programmable interconnects

One of the main reasons that we've come so far so fast with computers is *programmability*. Custom circuitry is no longer required for all projects. Instead, computers are a "one size fits all" high-volume product that can be "taught" to do many different things.

There are scads of programmable ICs available today: PROMS, which are programmed by blowing internal fuses; PAL, GAL, and PLA logic circuits that have programmable links; flash memory that can take non-volatile "snapshots" of their data contents; and, of course, microcontrollers with built in EEPROM memory.

Wouldn't it be handy if you could *software* program an *entire* circuit as well? No matter how many chips were involved? Being able to do so would dramatically reduce circuit development time. It would greatly simplify all testing and debugging. Later modifications or field upgrades would also be much easier.

Hobby electronic labs for beginners provide full programmability, as did my older CMOS *Microlab* and *Digital Logic Microlab* projects published way back in *Popular Electronics*. Electronic prototype breadboards also deliver programmability, and the whole idea behind wire wrapping is to accomodate changes in an existing circuit.

But those all have flaws. The connector systems are expensive and demand many hours of work for manual and mistake-prone hookups. Factors such as stray capacitance and crosstalk cause problems, speeds are severely limited, and testing lots of points can be a chore. Thousands of connections would be needed for even a medium-sized project these days. And for every copy of your job, you would have to repeat the entire process.

Instead, there are some brand new concepts that involve *programmable interconnects*. Those are methods for connecting or changing the wires conducting signals *between* dozens or more IC packages.

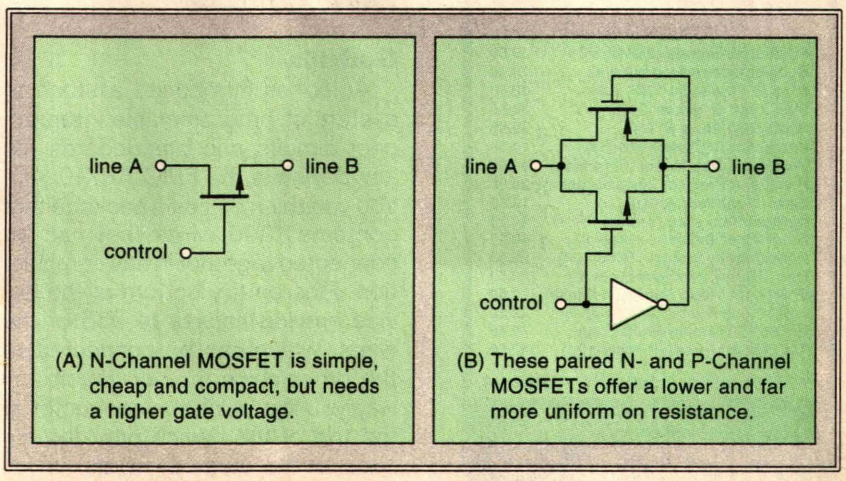
Let's look at a pair of solutions to the problem of programmable interconnect. One is high-end, the other one is cheap and eminently hackable. But before we look at those, let's quickly check into...

Transmission gates

For a programmable interconnect, what you'll need is a great heaping bunch of simple, ultra-cheap switches. Ideally, the switches will provide a perfect open or a perfect short circuit.

A few compromises are needed. First, we'll forget about programming all the supply and ground leads. They have to be short and have low-impedance, and there are not all that many of them anyhow. We'll also forget about any programmable interconnects for high-power or extremely high-speed circuits.

Figure 1 shows two *transmission*



(A) N-Channel MOSFET is simple, cheap and compact, but needs a higher gate voltage.

(B) These paired N- and P-Channel MOSFETs offer a lower and far more uniform on resistance.

FIG. 1—TRANSMISSION GATES act as bidirectional switches.

gate circuits that either isolate two lines or connect them together with a low-value resistance.

Figure 1-*a* is simply an N-channel MOSFET transistor. If the gate is a few volts higher than either line, the transistor turns on and looks like an ordinary resistor. Digital or analog signals can be routed through the transistor *in either direction* when it is turned on. There are no saturation effects or direction restrictions. Nor is there any difference between input and output. The resistance values measured here would be 50 ohms when the transistor is on and tens of megohms when it's off.

A single transistor switch can be cheap and compact, and that's just what we'll need if we want to get serious about putting 25,000 of them (!) inside one programmable interconnect chip.

A disadvantage is that the gate needs a higher voltage supply than the rest of the circuit. Because currents are low, a charge pump can supply that voltage.

A classic CMOS transmission gate is shown in 1-*b*. Here we place an N-channel transistor in parallel with a P-channel one. The on resistance is then lower and more uniform. We can also eliminate the need for any higher gate voltages because the N-channel device works best when near ground and the P-channel device works best near the positive supply.

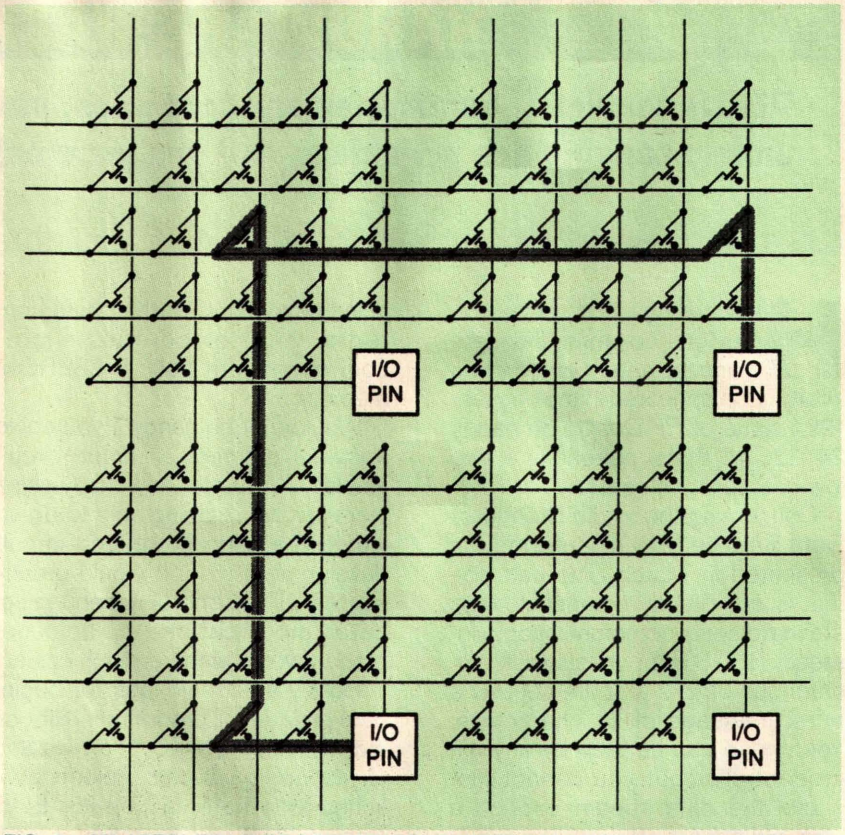


FIG. 2—AN APTIX FIELD PROGRAMMABLE INTERCONNECT can be considered a magic box that lets you instantly connect any of a thousand wires together in any manner you like. Here's how the "three hop" internals are arranged.

Typical CMOS transmission gates are the 4016 and 4066. Those have 15 to 60 ohms of on resistance. More details on transmission gate fundamentals are shown in my *CMOS Cookbook*.

Godzilla

Aptix has introduced a stunning system of programmable interconnect circuits and breadboards. Its key device is the FPIC APX1024D. You can think of it as a package that contains 1000 wires that can be connected together in any combination. Pins on the bottom of the device provide access to 936 of the wires, which can be connected to the other chips in your circuit any way you like. A ribbon connector at the top of the device provides access to the other 64 wires, which are normally used for testing and debugging. They can be connected to *any* of the other wires on the fly.

At first glance, the obvious way to connect a thousand things together in any combination is to build an array that is 500 wide by 500 high. But that would mean that a total of 250,000 gates would be needed. It is unlikely that you would ever need that many connections.

Instead, the interconnect system of Fig. 2 is used. Each I/O or test pin has a short vertical stub that can be connected to up to four horizontal routing lines. Each I/O also has a short horizontal stub which can go to four vertical routing lines. Between each I/O pad, four horizontal routing lines can be connected to any of four vertical routing lines. This scheme needs only 24 transmission gates per I/O pad, for a total of 24,000.

Some of the routing lines are long distance "express" lines, while others are "local" lines that short hop across only a few pads. Typically, you'll need *three* series transmission gates for any connection: The first one connects the pad to a

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horizontal routing line. The second connects the horizontal routing to a vertical one. And the third connects the vertical line to the second pad.

Each transmission gate is a simple NPN transistor that is driven from either ground (when off) or the +7.5-volt supply (when on). The average three-hop connection should end up around 150 ohms with 25 picofarads of stray capacitance. Analog crosstalk will be less than one percent, or 40 decibels down. The pins themselves can handle any signal analog or digital within a 0 to +5-volt range.

Although these transmission gates are all bidirectional, there are routing advantages to defining certain pins as input only or output only. There are also methods for the *critical routing* of speed-sensitive runs.

A portion of the circuitry is a serial-to-parallel converter. As many as a third of a million bits are received to initialize the device. Once programmed, the on-off patterns are stored in static RAM.

The memory is volatile, meaning that it forgets what it has been taught when power is shut off. Initialization can be performed by a host computer or with a special stand-alone module.

It is possible to run out of routing lines. But that problem might be solved with careful layout. A similar problem is encountered with gate arrays and other large programmable ICs.

There are many other programmable-interconnect devices and systems in the line. The Aptix AX1024R is essentially the same device in a cheaper package with-

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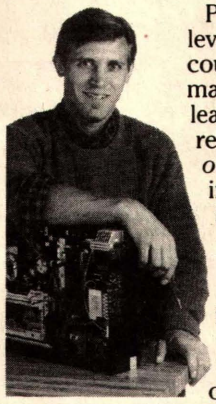

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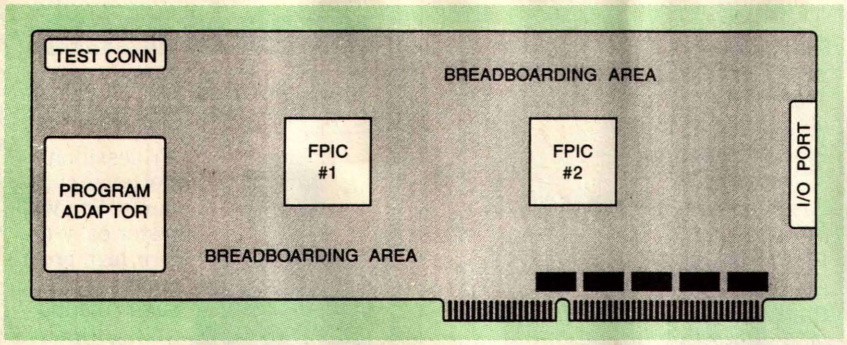

FIG. 3—THE APTIX FPCB AXB-AT2 is a plug-in card for an IBM PC that lets you quickly connect and debug up to 1700 interconnections on 37 square inches of digital or analog circuitry. Dozens of chips can be accommodated.

out the breadboarding connector. Several cards are offered with one or two programmable interconnect chips and lots of breadboarding areas. One of these is the FPCB AXB-AT2, an IBM PC-compatible plug-in card with programmable interconnects. It can make a total of 1700 connections. Included are breadboarding areas, a test and debug connector, and the usual bus driver ICs. Dozens to hundreds of ICs can be used for the main circuit.

Lots of additional solder pads are provided for supply and ground connections. With some adapters, the layout pattern could accommodate just about any shape or size of IC. A special area piggybacks a startup device. Figure 3 shows a pictorial of this plug-in card.

At first glance, the Aptix system seems horribly expensive. The ICs are in the $700 range and the breadboards are even higher. But the potential time and dollar savings of programmable interconnects makes this initial cost of the system seem trivial.

We might soon expect some major improvements. Costs might be driven lower because of competitive devices and higher sales volume. Other improvements include lower on resistances and stray capacitance. And, of course, nonvolatility in the form of internal EEPROM or flash memory is a must. High-voltage units for analog design would also be a nice addition.

It should eventually dawn on Aptix that smaller hacker offerings without all the bells and whistles and gold plating could be a real big seller. Aptix has a free video, a data book, and other technical information available.

A low-end solution

Pioneer Semiconductor has some programmable interconnects that are cheaper and much more hacker friendly—albeit at much lower package densities. Costs are as little as $2.40 each.

Each chip typically offers eight to twenty transmission gates in various arrangements. The gates themselves give a much higher performance with an on resistance of 5 ohms and stray capacitance of 6 picofarads.

One model in particular that has attracted me is the PI5C3383. This one holds five double-pole, double-throw bus switches. It would be useful for data switches, especially for those related to SCSI communication. Another use for programmable interconnects is as an intelligent serial cable setup that can be made instantly configurable on the fly. Details are in Fig. 4.

In use, the *bus select* line picks A to C outputs when it is low and A to D outputs when high. The *bus enable* line floats the outputs when high and activates them when low. As before, the bus switches are bipolar and can allow digital or analog signals to go either way inside a 0 to +5-volt DC range. Switching times are six nanoseconds or so.

A *zero* propagation delay has been claimed because no amplifying or switching devices are involved. You will, of course, still have the delay caused by all the circuit strays. Many package options are offered, from a 24 pin DIP down to a quarter size surface mount QSOP.

Now, if we could only convince Pioneer to make much larger chips or Aptix to build much cheaper ones, we would be all set.

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A contest

Let's make a contest out of this. Just tell me about some new programmable interconnect uses. Assume that cheaper and mid-sized circuits will shortly be available.

There will be the usual *Incredible Secret Money Machine II* books going to the dozen best entries. An all-expense-paid (FOB Thatcher, AZ) *tinaja quest* for two will go to the very best of all.

As always, send all of your *written* entries to me here at *Synergetics* and not to the *Electronics Now* editorial offices.

Pinball resources

There's a lot of interest in pinball machines these days. As this month's resource sidebar I gathered together the names of a few sources of more pinball information.

If you are primarily interested in machines as an income source, check into *Play Meter* and *RePlay*.

There is a surprising number of labor-of-love newsletters and magazines in the field. These include *Gameroom*, *The Flipside*, *Pingame Journal*, *Pinball Trader Newsletter*, *Pinhead Replay*, and the *Silverball Express*.

As with any specialized field, there are dozens of viable suppliers. I've shown a random sampling here, but the one with the neatest name has to be *Pinball Lizard*. *Steve Campbell's Pinball Pages* is a good place to go for schematics, manuals, and instructions.

Silverball Express also has a more extensive resource directory than I've shown here. Included are the leading manufacturers and, in my view, the best books.

Thanks to Marc Mandeltort of *Marco Specialties* who put me on to many of these resources. Marc is one of our *tinaja quest* winners.

New tech lit

A free tutorial note on MIDI and wavetable music synthesis is offered by *Crystal Semiconductor*.

Steve Jobs and the NeXT Big Thing is a new book by Randall Stross published by *Atheneum*. While it is somewhat harsh, the book explains what happens when far too much money and far too much ego are thrown at a non-solution to a non-problem.

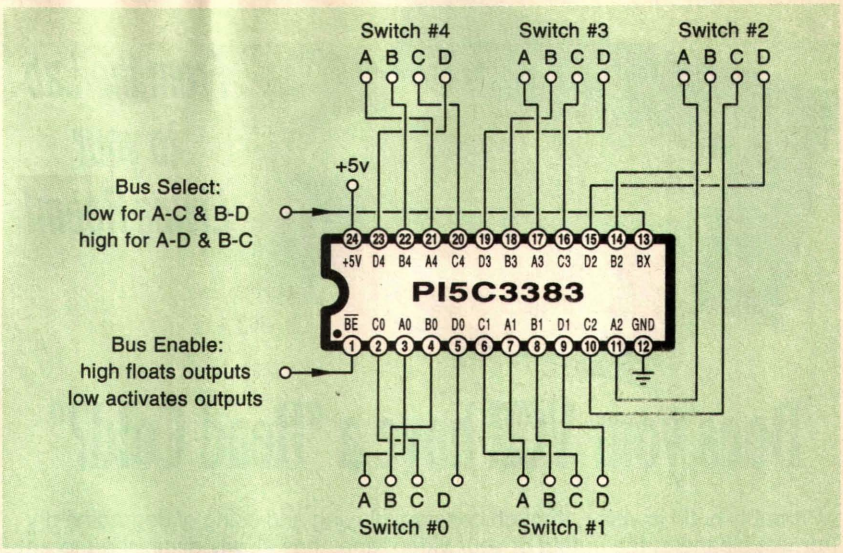
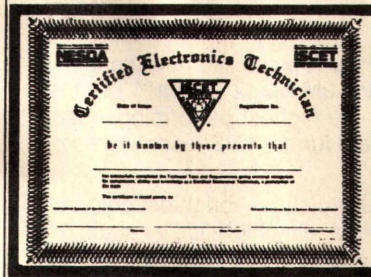


FIG. 4—THE PIONEER PI5C3383 BUS SWITCH holds five double-pole, double-throw bidirectional switches. This one is ideal for SCSI switching.

You can now make custom printed circuit boards in minutes for pennies. Frank Miller of *DynaArt Designs* has just expanded his line of direct-toner printed circuit products. He now offers special toner cartridges, his new hot lamination transfer system, and a new gentle wave etcher. More on these if I get a chance to test them out.

Sensym offers free samples of its SDX pressure transducers to qualified potential quantity buyers.



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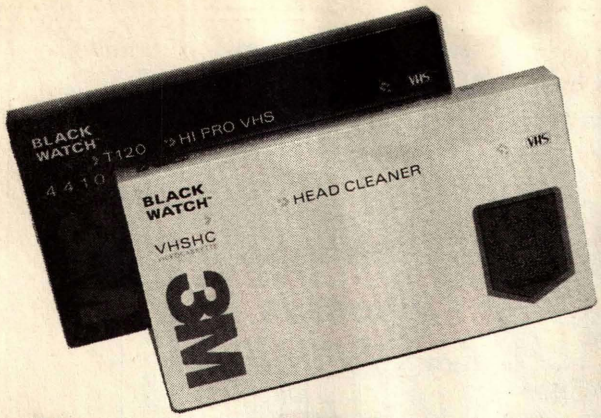

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Pressure ranges go down to 0–1 psi. Its 0–5 psi model looks real useful for measuring water levels to twelve feet.

Free *Fybrglass* brush samples are available from the *Eraser Company*. They are ideal for cleaning PC boards before soldering.

The *Grapevine Group* offers hard to find *Commodore* and *Amiga* parts.

A new low-cost scoring system that is ideal for making your own boxes, cardstock models, and book covers is offered by *Martin Carbone*.

Check the Oil is a newsletter for all collectors of antique gas pumps. The *Human Powered Vehicle Association* publishes both a *Human Power* technical journal and a *HPV News* newsletter. The letter covers the surprisingly sophisticated engineering of bicycles, recumbants, boats, kinetic art, aircraft and even submarines. No spacecraft yet.

Electro- and Magnetobiology is a pricey journal from the *International Society for Bioelectricity*. This one is published by *Marcel Dekker*.

Skin electrodes for brainwave and EKG research are available from *In Vivo Metric*. Competing ads are in *Medical Equipment Designer*.

I also have a brand new catalog with a much larger insider secrets section. You can write, call, or E-mail me at [SYNERGETICS] on *GEnie* or SYNERGETICS@GENIE.GEIS.COM on the Internet for your free copy. Or download it directly as SYNCAT1.PS from *GEnie* PSRT.

Speaking of *GEnie*, I have newly posted several cute PostScript hacks there. No. 843 on custom filters, No. 861 on sneaky server modifications, and No. 868 on my new picojustification scheme. Ω

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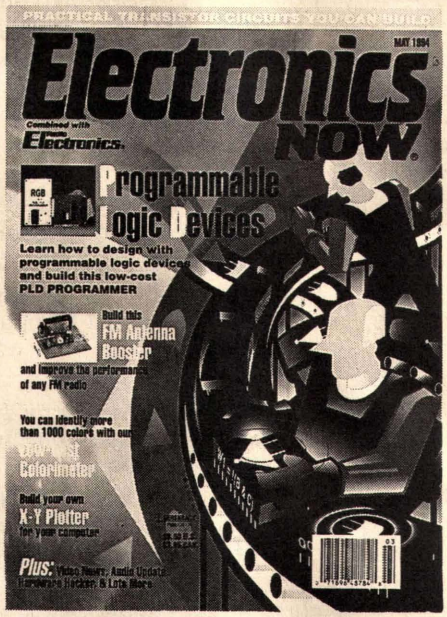

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Crystal Balling the Future

LARRY KLEIN

Anyone who writes a column is faced with an ongoing temptation. As the information pours in, the urge to pontificate and prognosticate becomes almost uncontrollable. The illusion of special insight that afflicts pundits such as myself results in a plethora of magazine articles and books all predicting tomorrow's events. There's even a term for such modern-day Nostradamuses—they're called Futurists.

I usually confine myself to forecasts of the success or failure of new types of products, and my batting average over the years has been pretty good. For example, a 1970 preview of the Dolby-B cassette noise-reduction system provoked me to predict that it could/would make the difference in the future of cassettes as a music medium. (It happened, but I didn't understand at the time how little the major manufacturers of prerecorded tape cared about recording quality. The adoption of Dolby-B as a recording standard did cut the noise in home taping, but it didn't do much for commercial recording. That's another story, however.)

I could list my predictive hits and misses on product viability over the years, but I've done that elsewhere. What I'd like to look at is the broader question of technology trends. In 1977, in celebration of the one-hundredth anniversary of Edison's invention of recording, I wrote my first (and only) science fiction story to be published in a magazine. It was an imaginary look backwards from the year 2077 chronicling the evolution of recording from 1977 on.

Technology chronology

Rereading my piece 17 years later, I'm struck not by my calls and miscalls, but by the items that I thought were pure fantasy but that nevertheless came to pass. For example:

The turn of the century saw LSI chips with million-bit memories—and the eruption of two controversies, one major and one minor. The major controversy would have been familiar to our ancestors who were involved in the cable-versus-broadcast TV hassles during the 1970's and later. The big question in the year 2000 was the advantage of "time-sharing" compared with "resident" computers for program storage.

Since the 1950's, the need for fast output and large memory-storage capacity has driven designers into ever more sophisticated devices, most of them derived from fundamental research in solid-state physics. The late 1970's, a period of rapid advances, saw the primitive beginnings of numerous different technologies, including the charge-transfer device (CTD), the surface acoustic-wave device (SAW), and the charge-coupled device (CCD), each of which had special attributes and ultimately was pressed into the service of sound-reproduction processing and memory. The development of the technique of molecular-beam epitaxy (which enabled chips to be fabricated by building up layers of molecules with molecular beams) eventually led to superconductor (rather than semiconductor) LSI's and molecular-tag memory (MTM) devices. Super-fast and with a fantastically large storage capacity, the MTM chips functioned as the heart of the pocket-size ROM cartridge (or "cart," as it was known) that contained the equivalent of hundreds of primitive LP discs.

The read-only memory of the MTM carts could provide only music that had been "hard-programmed" into them. That was fine for the classical-music buff, since it was possible to buy the complete works of, say, Bach, Beethoven, and Carter in a variety of performances all in one MTM cart and still have molecules left over for the complete works of Stravinsky, Copland, Smythe, and Kuzo. However, anyone concerned with keeping his music library up to date with the latest Ramarock releases or Martian crystal-tone productions obviously needed a programmable memory. But how would the new program get to the resident and in what format?

By this time, every home naturally had a direct cable to a master time-sharing computer whose memory banks were constantly being updated with the latest compositions and performances. That was just one of its minor facilities, of course, but music listeners who subscribed to the service needed only request a desired selection and it would be fed to and stored in their RAM memory units. Those audiophiles who derived no ego gratification from owning an enormous library of MTM carts could simply use the main computer feed directly and avoid the redundancy of storing program material at home. Everyone was wired anyway, directly or indirectly, to the National Computer by ultra-wide-bandwidth light-guide cable. The cable normally handled multichannel audio-video transmissions in addition to personal communication, bill paying, voting, etc.—and, of course, the Transfax printout that you are now reading.

I didn't anticipate CD-ROM's, but my description of the ROM cartridge was pretty close.

After the article appeared, two phone calls came into my office. One was from a woman who identified herself as being from a government agency whose name I didn't recognize. She wanted further information on the molecular-tag memory devices. I told her that there was no further information since I made them up. Yes, she said, but what were they based on? My imagination, I replied. Yes, but what ..., etc.,

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etc. At the point our conversation terminated, I'm sure she felt I was holding something back, but I heard nothing more from her.

The second phone call was from a senior editor at *Science News*, an authoritative science newsletter. He also wanted my reference sources for the MTM devices. When I told him that I had invented them myself, he expressed surprise. Since they were introduced in my article as the end result of a series of existing semiconductor developments, what was the source of that information? *Science News*, I replied—thus closing the circle and our conversation.

About a year ago, I read somewhere about the experimental use of single molecules as digital switches. And my local fiber-optic cable system (TCI) now has available a programmable digital music setup. I'll let you know how well it works if I can persuade them to give me a trial run. It seems that things are moving faster than I thought!

If you would like a photocopy of my original article, send a stamped, self-addressed No. 10 business envelope to me at **Electronics Now**, 500-B Bi-County Blvd., Farmingdale, NY 11735. Ω

VIDEO NEWS

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• **Movie sound for TV.** The same digital sound system that is advertised as "DSD" (for Dolby Stereo Digital) in major movie palaces has been chosen as the sound channel for the Grand Alliance all-industry HDTV system, under the name AC-3.

Dolby Laboratories and Pioneer are currently working to make AC-3 the audio standard for laser discs. Those plans must be ratified by the Laser Disc Association. The system would supplement existing soundtracks on laser discs to maintain compatibility. The Dolby Digital AC-3 system spreads five audio channels around the room and adds an extra channel for subwoofer enhancement. AC-3 encoding squeezes the audio data into a bitstream running at the rate of 384 kilobits per second (kbps). Ω

EQUIPMENT REPORTS

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useful.

The SVR-2000 can also convert an oscilloscope into a waveform monitor. Its display shows waveforms as a voltage vs. time graph. The graticule can be read out in IRE units (along its left edge) and in percent modulation (along its right edge).

In its IRE filter mode, most of the color subcarrier is stripped out of the video signal so that the luminance (brightness) signal can be viewed alone (and therefore more accurately). A chroma filter is also provided so that the chrominance signal can be viewed alone.

The purchase of an SVR-2000 is an ideal way for a technician who doesn't specialize in the repair and testing of video circuits to acquire specialized video-testing equipment. Its $699 price should be especially attractive to anyone who has recently priced specialized stand-alone instruments. Ω

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PLD PROGRAMMER

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tion file and DIP-switch settings match—if they do, check the interface board for errors.

Programmer board set up

Double check the programmer board for shorts and other errors. Connect the 50-conductor ribbon cable connector to the programmer board and turn on the PC. If the PC does not boot up properly, the power supply is probably short circuited; shut off the PC and correct the problem. If the PC operates satisfactorily, run program RGBSETUP. Run through each of the tests in the setup menu (see Fig. 8).

The F1 key lets you the adjust the programming voltages. If the voltages are not present, check the section of the board with IC1, IC2, and Q1 to Q6. F2 and F3 let you check the +5-volt power to the ZIF test socket. The voltage at each of the power pins should be 4.75 volts or greater. If the power to the ZIF socket is unsatisfactory, check the power to the board, control signals VCC22 and VCC24, and the respective transistors. Pull-up resistors R10 and R11 and the ability to read data from the ZIF socket pins 14 and 15 are checked by F4. The functioning of each active pin on the ZIF socket can be checked by F5. Each active pin should toggle between a high level of 3.5 volts or more and a low level of 0.5 volt or less, relative to ground. If all tests are passed, the programmer is ready to be used.

Using the programmer

Start the program RGBPLD; the main menu is shown in Fig. 9. Selection F1 selects the device type to be programmed, either a 16V8A/B or 20V8A/B. Before placing a PLD in the ZIF socket, select the correct device type with F1. (*Caution: incorrect device selection could destroy the PLD.*) Selection F2 allows you to read a JEDEC file, the standard file format for transferring programming information. It contains all the programming information for the chip. Selection F3 performs a program and verify operation on the device in the ZIF socket. Selection F4 verifies operation. Selection F5 locks the security cell of the PLD. When the security cell is locked, the programming information in the PLD can't be read back. Selection F6 loads the device data into the memory that is used to make copies of the PLD. Selection F7 will write the JEDEC format file for the data loaded in memory. Key F10 to exit the program. The user electronic signature (UES) for both the main and verify buffer is always displayed at the top of the menu in ASCII format. During the program, verify, or load-device functions, LED illumination indicates that the ZIF test socket is active.

Programming process

Normal programming operations can be performed in one of two ways. First, always select the proper device type with menu option F1. If you are programming from a file, select option F2 to read a JEDEC file. When prompted, enter the appropriate file name.

For example, PLD1.JED is the JEDEC file for the GAL in the programmer. After the file is read, insert the GAL into the proper position in the ZIF socket and clamp the socket closed. To program the GAL, select F3.

The activity LED lights for a few seconds during the programming cycle, then extinguishes for about a second, and then lights again for a few seconds during the verify cycle. When the LED goes off for the second time, you can remove the GAL from the ZIF socket.

To make copies of a programmed GAL, select the device type, insert the GAL to be copied into the ZIF socket, select option F6 to copy the programmed GAL into memory, replace the programmed GAL with the GAL to be programmed, and select option F3.

National Semiconductor Corp. offers a free Logic Compiler called OPAL Jr. Send for a copy and you can start to design your programmable logic. Ω

PROGRAMMABLE LOGIC DEVICES

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counter used before). This counter provides several reference frequencies at the outputs; Q1 is half of Q0, Q2 is half of Q1, etc. With a 40-MHz crystal oscillator connected to pin 1, Q0 provides a 20-MHz clock, Q1 a 10-MHz clock, Q2 a 5-MHz clock, Q3 a 2.5-MHz clock, and Q4 a 1.25-MHz clock. The outputs SYSCLK0 and SYSCLK1 have identical equations, so they are together referred to as SYSCLK.

The SYSCLK outputs are combinatorial; they allow the system clock to be selected from Q0, Q1, Q2, Q3, Q4, or the inputs SELF or EXT. The inputs S0, S1, and S2 select which clock is output to SYSCLK. From the equations it can be seen that if S0, S1, and S2 are all 0, then SYSCLK is the same as the input SELF. If S0, S1, and S2 are all 1, then the last product term will apply and SYSCLK will follow Q0. The final output defined in the equations is WRDAT, which is just a simple two-input OR function. The equivalent circuit to this GAL is shown in the schematic in Fig. 5; notice the savings in chip count and cost that is typical of circuits implemented with programmable logic.

The equation file is compiled with the command line:

EQN2JED -N CLOCK

EQN2JED is the Opal Jr. program that produces the JEDEC file. It will check the CLOCK.EQN file for errors, and if it's error-free, it will produce the JEDEC file CLOCK.JED. The "-N" in the command line tells the program to produce a new log file rather than appending one to the existing log file. The log file produced is CLOCK.LOG. The log file contains a lot of interesting information about the programmed device, the use of each device pin, the product term usage, and the device pinout. CLOCK.LOG is shown in Fig. 6.

The CLOCK.JED file can be used by the programmer to configure the chip. The JEDEC file is shown in Fig. 7. Ω

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DRAWING BOARD

A closer look at our automotive power supply.

BOB GROSSBLATT

I've been writing this column for a long time and occasionally I forget that there really are people out there who read it. In the last month or so I've been reminded about this because of the response to my request for information about the error codes generated by car computers. I now have a bunch of information about this subject, and I realize that there's no way I can fit it all into a column—there's just not enough room.

I'm going to wait another month or so for other mail to come in, put it all together in a coherent form, and then either present it in the magazine or post it on the bulletin board—actually I'll probably do both. I'd like to extend a particular thank you as well as a tip of the hat (who remembers where that came from?), to K. Caldwell and Tim Granger for the massive amount of paperwork they sent me.

At the moment I have complete information for 1980–1987 Ford, Chrysler, and GM cars, as well as the code list for 1990 Chrysler Plymouths (I suspect that it's good for all the 1990 Chrysler products). If you have data for other years or cars, I'd like to hear from you.

It's a good thing I'm not a vegetarian because I also have to eat a bit of crow since I made a major mistake with regard to power-supply isolation. I don't know what was going through my mind when I wrote that column, but it's completely wrong. Not only was the math incorrect (13.5/.5 = 27, not 270), but the basic concepts that I used to explain the protection of the power supply were really more suited to an environment that is less hostile than the one found under the hood of your car.

While power-supply isolation is always a good idea in general, the particulars of it have to be tailored to the application. I have to admit that the material that appeared a few months ago was lifted from circuitry I designed for something else. Before I take this any further, a lot of you pointed out the mistake to me (some more kindly than others), but I'd like to extend particular thanks to Michael Crawford for suggesting some alternative schemes as well as hitting me on the head, and Rene Putinier for an interesting letter, a terrific application note, and several ideas that I should have thought of all by myself.

So let's take another look at power-supply protection.

There are several electrical nightmares that can show up in a car's electrical system, and each one has to be handled separately.

1. Low-voltage spikes—With an amplitude less than the 13.5-volt operating voltage, these spikes usually show up when you turn on or off some of the standard electrical devices in your car such as the fan, lights, or horn.
2. High-voltage spikes—these transients can be either positive or negative and often are as high as 500 volts! Needless to say, the higher the voltage, the shorter the duration, but even a few microseconds of a 400-volt blast can do an extraordinary amount of damage. These spikes are generated by arcing at the battery, jump starting the car, turning the car ignition off, and corrosion at the field connections on the alternator.
3. RF interference—this usually is not a big problem because the output of CB radios and cellular phones is pretty weak, and its effect can generally can be eliminated by putting your circuitry in a well-grounded metal box.
4. Human error—people sometimes put new batteries in back-

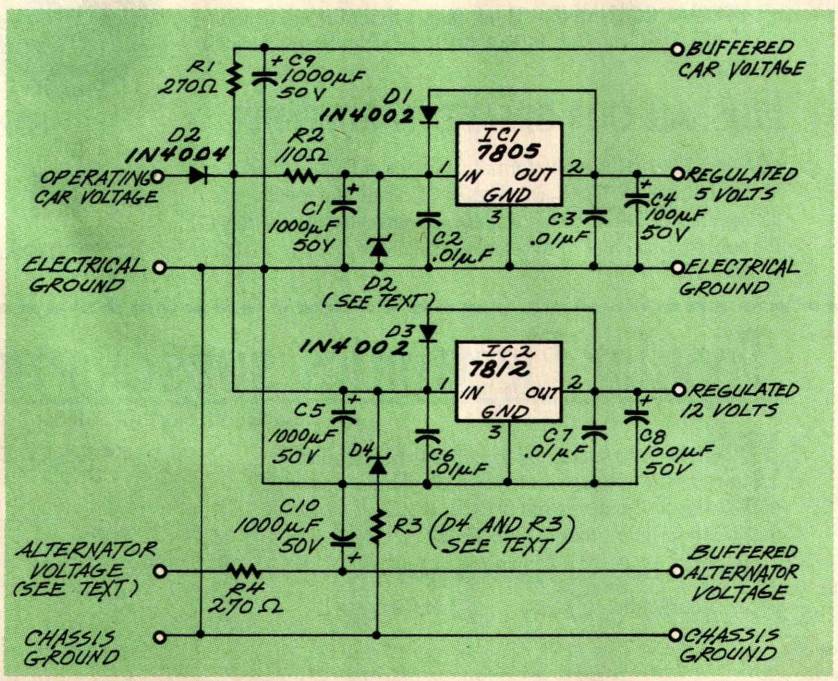

FIG. 1—A WELL REGULATED and protected power supply is necessary for semiconductor-based circuits.

wards (tell me why there's no standard polarized connector for car batteries). They also like to check whether or not jumper cables are well connected to a battery by briefly touching the ends of the cables together to get a spark. Last but not least, tow trucks frequently put two 12-volt batteries in series to get 24 volts and then use that to jump start your car. Their attitude is, as Rene noted, "If 12 volts is good, then 24 volts must be twice as good."

A simple way to guard against low-voltage spikes is with a basic RC filter arrangement but, as was pointed out by all of you who wrote me letters, this scheme limits the amount of current and is good only for low-power circuits. This is all well and good for CMOS-based control and measurement designs, but as soon as you start adding relays, LEDs, and other things, you're going to be in fuse-popping country.

One of the basic rules in life is that there's no such thing as having too much power available. You might start the circuit off needing only a few milliamperes, but you can bet your new pair of white tennis shoes that overall current requirements are going to increase later on.

After some thought on the subject, it strikes me that before you design the supply, recognize that not all components require the same kind of power. Semiconductor-based circuits need all the protection they can get from the incredible amount of electronic noise that's present in a car, but relays, solenoids, and LEDs really need protection only from spikes and other gross anomalies.

A well regulated and protected power supply is shown in Fig. 1. Because I was somewhat cavalier with myself last time around, I'll take each component in turn and see exactly what it does.

Since the voltage supplied by this part of the supply is going to be so well isolated from the fluctuations in the car, it should be used for the circuitry that's most sensitive and, as you undoubtedly know, it is the CMOS section. Given that, you can safely assume that having an outside limit of 100 milliamperes is going to be fine. Remember that a second supply can always be added if necessary.

The resistor calculation, which I screwed up last time, is going to be the car voltage (13.5) less the voltage drop across the regulator (about 2.5 volts) divided by the maximum amount of current you want. Doing the arithmetic (using a calculator this time), you get an answer of (13.5 – 2.5)/100mA, or about 110 ohms. If you try to draw more than 100 milliamperes from the regulated supply, the voltage across the regulator is going to drop, and thus the 5-volt supply is going to drop out of regulation.

The people who wrote in with comments about the 12-volt supply were correct in that the use of an isolation resistor with the regulator wouldn't leave enough voltage for the regulator to operate. Although the 7812 spec sheet calls for an input voltage that's 2.5 to 3 volts higher than 12 volts, I've used them successfully with as little as a 1.5-volt difference. Because I assume that the car will be running at 13.5 volts, the 1.5-volt difference should be fine.

That is cutting it a bit close though, so you might think about changing the regulator from a 7812 to a 7809; this 9-volt part will operate perfectly in a car. Moreover, the only reason you would need a super-protected 12-volt supply would be for powering specialized semiconductor devices such as sensors, reference voltages, and other low-power devices.

Because there's only a 1.5-volt difference between the absolute minimum voltage required by the 7812 and the car's voltage, an isolation resistor can't be used. You will, however, still protect the regulator against spikes and polarity reversal. If you need isolation on the 12-volt line, you can use (as Rene pointed out) other regulators that have a lower dropout voltage such as the LM2931 that needs only 0.6 volts to operate.

Protection against power reversal can be accomplished by adding the diode (D2) as shown in Fig. 1. That adds a 0.6-volt drop to each input leg of the supply, but the advantages outweigh the consequences. There's enough headroom on the 5-volt leg to handle the diode's voltage drop, but using it on the 12-volt leg means you'll definitely have to use a low-dropout regulator or a part like the 7809. Again, it depends on what you plan to power with the higher voltage.

If you definitely need a 12-volt supply and insist on having it both isolated and regulated, it's always possible to build a DC-to-DC converter to raise the regulator's input voltage. The down side of this is that these schemes won't produce much in the way of usable current and can often generate some really dirty DC so you'll have to do some work if you want to increase the current output at 12 volts.

Overvoltage protection for the inputs is assured by the RC combination on the 5-volt leg, but it's really nonexistent on the 12-volt supply. The capacitor can soak up spikes, but a series of repetitive high-voltage spikes or an overvoltage condition that lasts longer than the RC time can still destroy the regulator as well as the rest of the supply. You can guard against this with a Zener diode (D2) as shown since it will start conducting if the voltage at the regulator input ever exceeds the Zener's breakdown voltage.

The value of the Zener diode depends what you want to protect, but a 15-volt Zener is usually a good choice. Just about the only time I would expect a protracted period of high voltage would be if 24 volts were used to jump start your car. Since that voltage would make the Zener conduct and shunt all power from the regulator, anything powered by the supply wouldn't be operating during the jump start. If you think about it, that's really not such a bad idea.

There are other schemes you can use to protect the power supply, but you're the one who has to decide if they're really needed. The use of a small coil on the main input leg will keep the current down for a short time, but the price paid for having it in the circuit is that you'll need a much larger capacitor to absorb the pulse generated by the coil. As I said, you have to figure out what's needed for your applications. Standard instruments, such as a tachometer, will probably be happy to

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be fed power by the circuit shown in Fig. 1.

The last consideration when designing the power supply is to remember that not all cars are the same. My old Jaguar is the greatest car ever made, but it's the electrical equivalent of the world's cheapest hair dryer. The ignition system regularly emits two spikes for each plug firing. The first is at least 20 volts and the second is about 5 volts. This is due to the design of the ignition system, and there's no easy way to fix it.

More modern cars are a lot quieter. Just as an aside, you wouldn't believe the extent of the work I had to do to keep alternator noise out of the radio!

When we get together next time we'll do some fun stuff and continue working on the tachometer. Again I apologize for the mistakes I made but I have to tell you... crow isn't half bad if you bake it in a slow oven at 350 degrees. Ω

WHAT'S NEWS

continued from page 6

patents in 1993, giving it the distinction of being the first American company to lead the world in the number of U.S. patents granted since 1985.

According to Marshall Phelps, an IBM vice president, most of the patents related to information processing. However, he noted that among the patents granted that were not related to software were those for a high-repetition laser, an environmentally safe solvent, and a folding computer keyboard. IBM was granted 27% more patents in 1993 than it was granted in 1992, when it ranked No. 7 on the list of U.S. patent recipients.

Japanese companies still held seven out of the ten top positions in patents granted—just as they did in 1992. Toshiba and Canon were in second and third places, respectively, behind IBM. Eastman Kodak, the camera and film company, showed up in fourth place with 1008 patents.

Multimedia patent granted

Compton's New Media, Carlsbad, CA, was granted United States Patent Number 5,241,671 for a multimedia database search system that uses a database consisting of text, picture, audio and animated data. The issuance of the patent is expected to have far-reaching implications for the fast-growing multimedia industry.

Compton's NewMedia applied for the patent just after the 1989 release of "Compton's MultiMedia Encyclopedia," the first electronic encyclopedia to integrate pictures, sound, motion, and multiple entry paths. Unlike other CD-ROM-based products of that time, Compton's product provided the ability to explore databases of text or graphics that can be interrelated yet searched independently of each other. The concept is not limited to CD-ROM's on personal computers; other multimedia platforms include the Macintosh, Philips' CD-I, and Tandy's VIS.

Comptons is seeking licensees for its multimedia technology. The licensing program will provide several options for developers. They could enter a strategic joint venture relationship with Compton's NewMedia, enter into a distribution arrangement with the Affiliated Label Program, develop a product using Compton's SmarTrieve technology, or pay royalties.

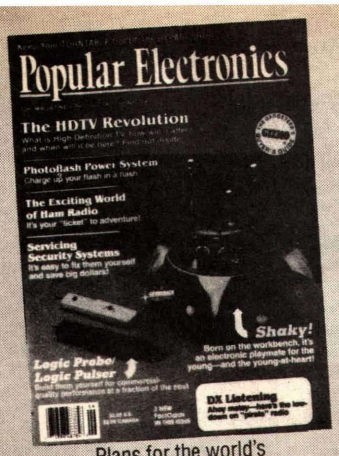
A new bachelors degree in electronics.

The Cleveland Institute of Electronics (CIE), a correspondance school, has opened World College in Virginia Beach, VA, to offer a Bachelor's Degree in Electronics Engineering Technology (BEET).

The new college has been authorized by the Virginia Council of Higher Education to enroll students in the BEET program, and the college is seeking approval from the Council to confer the BEET degree.

World College is accredited by the Accrediting Commission of the National Home Study Council, a non-profit, voluntary association of accredited home-study schools.

For information concerning World College and the BEET program, call 800-243-6446. Ω



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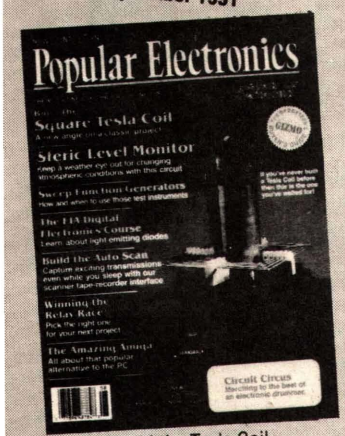

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COMPUTER CONNECTIONS

General Magic has something up its sleeve.

JEFF HOLTZMAN

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If any of those statements apply to you, you're going to be interested in a group of technologies developed by a company called General Magic.

General Magic is a spin-off of Apple Computer; two key technical managers were members of the original Macintosh design team, and another was involved in development of the the X.400 and X.500 network/E-mail standards. General Magic's boards of directors and advisors reads like a global "Who's Who" of visionaries in graphics, telecommunications, and consumer electronics.

General Magic has formed an alliance of companies, each of which licensed its technologies and plans to introduce products based on them. Neither Microsoft nor IBM is involved. But Apple, AT&T, Matsushita, Motorola, Philips, and Sony are. General Magic has also enlisted a cadre of leading-edge computer-industry software developers including America Online, Intuit, Mead Data Central (known for its Lexis and Nexis on-line databases), Official Airline Guides (OAG), Oracle, PenWare, SkyTel, RadioMail, Sony Electronic Publishing, and numerous others.

What does it do?

The General Magic technologies include both hardware and software. The hardware is a handheld communicator, much like Apple's Newton MessagePad. The software enables a communicator, as well as a standard PC or Macintosh, to communicate with ease. The series of screen shots in Fig. 1 were taken from a prototype communicator, and they illustrate the friendly nature of General Magic's software environment.

The environment provides three "places:" a desktop (*a*), a hallway (*b*), and downtown (*c*). By tapping a given object—e.g., the telephone, the in-box, or the planner—in one of those places, a new screen pops up. For example, you might display a telephone database/dialer (*d*), a notebook (*e*), or a fax application (*f*).

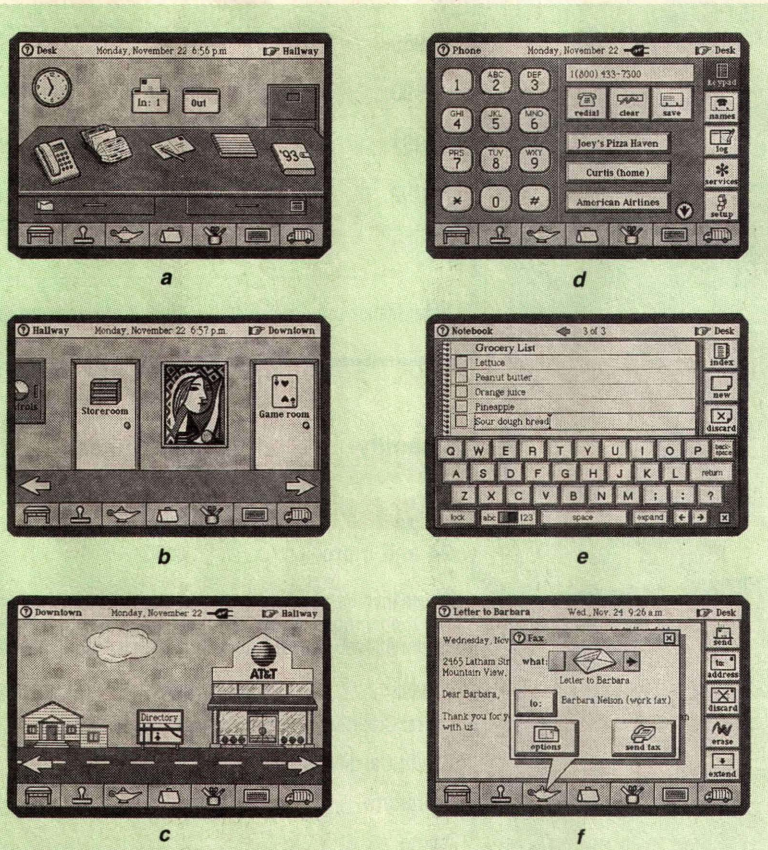

FIG. 1—GENERAL MAGIC'S MAGIC CAP provides a friendly environment for performing communications-related tasks. It's central user-interface metaphors center around a desktop (*a*), a hallway (*b*), and downtown (*c*). Magic Cap also includes several mini-apps, including a phone dialer (*d*), a notebook (*e*), a fax application (*f*), and more.

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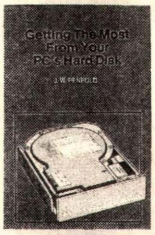

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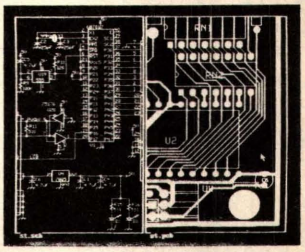

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Hardware and software

General Magic is not a hardware manufacturer. Nonetheless, it has defined a "minimum functionality specification" (MFS), shown in Table 1, that any certified compatible device must meet. General Magic partners and consumer-electronics giants Matsushita, Motorola, Philips, and Sony are building compatible communicators, which should be released in the second half of 1994.

The software comprises two components: Magic Cap and Telescript. Magic Cap is an operating environment and a user interface, not a complete operating system. By analogy, it is more like Windows 3.x—without DOS—than OS/2 or Macintosh System 7. General Magic states that Magic Cap "provides powerful building blocks that enable independent software developers to create new applications and services," and further describes it as "an object-oriented, communication-centered platform for development." Magic Cap does not provide handwriting recognition. Magic Cap runs on personal communicators; it also runs like any other application under Windows and System 7.

Telescript is a behind-the-scenes technology with no user interface. Like PostScript, it is a programming language. PostScript specializes in representing graphical and font information in a device-independent manner. Telescript specializes in performing communication-oriented tasks in a network-independent manner. Like PostScript, Telescript is interpreted at run time from strings of ASCII text.

Every PostScript printer or video windowing system (e.g., NextStep, now known as OpenStep) contains a PostScript interpreter, a software "engine" that reads the ASCII-based programming instructions and makes and erases marks on the host output device accordingly. Every PostScript *interpreter* is different, depending on the nature of the output device (resolution, color depth, page rate, etc.). But the PostScript *language* is always the same. In most cases, an application can write the same page-description code—i.e., the same PostScript program—with no knowledge of the output device, whether it is a $1000 laser printer, a $50,000 imagesetting machine, a video screen, a sign cutter, or something altogether different.

In like fashion, applications that use Telescript can deliver the same communications code to various network connections, regardless of the underlying link technology (e.g., Ethernet, Token Ring, or asynchronous modem). Hiding the gory details of network programming is a brilliant concept. I hope that General Magic does not try to keep it locked under veils of proprietary secrecy as Adobe originally did with PostScript.

In any case, General Magic has applied these technologies to a simple yet compelling vision of the next step in the information revolution: information "agents" that travel the information superhighways searching for the goods, services, and information that we want. As users, we interact with these agents on handheld communicators and standard desktop computers. Of course, the concept of agents did not originate with General Magic. What is unique is the way the company has encapsulated messy network transports and protocols so that they can be dealt with in a conceptually clear and unified manner.

What's the relationship between Magic Cap and Telescript? Just as every PostScript printer must run a PostScript engine to interpret PostScript code, every "place" on a network must run a Telescript engine to interpret Telescript code. This means that every Magic Cap communicator runs a Telescript en-

gine, as must every node to which it could connect. For example, America Online has committed to running a Telescript engine. Therefore, any Magic Cap communicator will be able to interact with America Online, as would any PC or Macintosh running Magic Cap.

America Online already has a user interface—and a pretty good one at that. What do Magic Cap and Telescript do that America Online can't do by itself? From a user's viewpoint, General Magic technology could provide a unified front end not only to America Online, but also (conceivably) to CompuServe, a corporate database, and perhaps even the Library of Congress.

From a software developer's viewpoint, the uniform programming interface provided by Telescript can drastically simplify the job of developing applications. That in turn allows developers to focus more on defining and meeting user requirements, and less on the intricacies of communicating data via this or that network protocol.

In essence, an agent is a Telescript program that is sent to do a job. Once an agent arrives at a destination, it typically interacts with another agent, perhaps a supervisor or manager of local resources, or a tour guide, or an authenticator. *How* an agent arrives at a destination is moot, and that's the beauty of Telescript.

Silver lining?

General Magic's literature focuses heavily on commercial applications of its technology. Primarily, the company is promoting the idea of shopping malls—*electronic* shopping malls. In this view, the primary purpose of agents is to seek out goods, services, and information, and to return them to the requester. By itself, this commercial focus is neither good nor bad. But if Telescript technology ends up being used exclusively for commercial purposes, it might, at best, achieve limited appeal.

The reason for its limited appeal is that there is a lot of information in the public-domain available from educational and research institutions, primarily through the Internet. Will these institutions have to pay a significant licensing fee to run a Telescript server? The U.S. Government also has reams of data that is, by definition, public domain—but it's expensive or impossible to get. Can we envision the Library of Congress, the Department of Commerce, and the Advanced Research Projects Agency (ARPA) running Telescript servers? Who will pay for them? Could the commercial users, the "Magic Cap Home-Shopping Network," subsidize the effort, much as business telephone use has long supported private use?

TABLE 1
MINIMUM FUNCTIONALITY SPECIFICATION

Magic Cap software
Data/fax modem
IR communications
PCMCIA card expansion
Microphone
Speaker
Motorola 68349 CPU
480 × 320 × 4 pixel LCD touch screen
3 MB of ROM
1 MB of RAM

There are other potential difficulties, not the least of which is the problem of bootstrapping a new industry into existence. Without paying users, service providers might be reluctant to commit dollars toward developing creative new services. And without compelling new or at least cost-effective old information services, users might be reluctant to buy into the technology.

There are technical problems with the communicators as well. Screen resolution is limited; color might or might not be available; and the lack of a keyboard will surely push many mobile users toward traditional portable computers. It is possible to do everything with them that a Magic Cap communicator can do, although the user must do more work. The Magic Cap's HyperCard-like user interface is certainly compelling at first glance. But its two-dimensional navigational structure may prove limiting as users' needs increase.

The technical difficulties might be overcome by the time real products are introduced later this year. But the larger issues remain.

The concepts behind Telescript are brilliant. Telescript, or something like it, is destined to become for the telecommunications industry what PostScript has become for the publishing industry: a standard, something simply taken for granted. Magic Cap, on the other hand, is just another operating environment, although one with some compelling features.

Happy birthday

This past January 24th marked the 10th anniversary of the birth of the Macintosh computer. On that date in 1984, Apple introduced the original Macintosh, which was based on an 8-MHz 68000 with 128K of RAM. It also introduced the concept of the graphical user interface (GUI) to a skeptical business world. It took six more years and the release of Windows 3.0 for Apple's vision to be vindicated.

Apple's original marketing concept was severely flawed: It proclaimed the Mac as "the computer for the rest of us." Yet for most of that ten-year history Apple priced it considerably higher than an equivalent IBM-compatible PC. The company also hid both the hardware and the software under a proprietary shroud that only now is it beginning to lift.

Apple tried to sue both Microsoft and Hewlett-Packard for copying elements of the Macintosh interface; over the course of many years and millions of dollars, the suit was gradually dismantled. Anyone with a knowledge of the history of the computer industry knew that most GUI concepts did not originate with Apple, but rather with Xerox half a decade before. Ironically, beta versions of the upcoming release of Windows 4 provide an even more Mac-like interface that is complete with nested folders, exploding windows, and loss of the distinction between Windows' Program Manager and File Manager.

Nonetheless, throughout it all, Apple has exhibited a sense of persistence and dedication to a vision that was initially derided, but is now taken for granted. Don't forget history. Give credit where it is due. May Apple's next decade prove as visionary as its first. Ω

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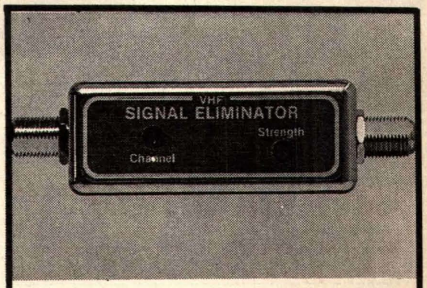

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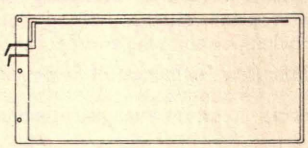

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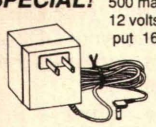

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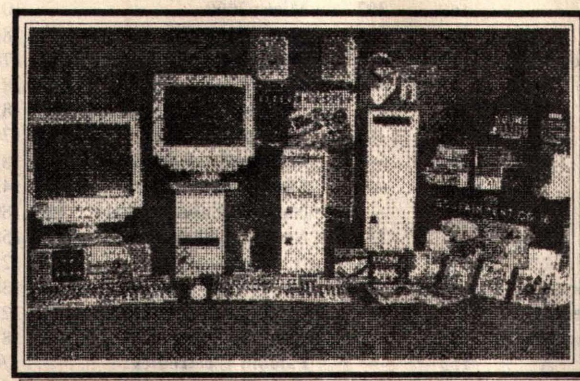

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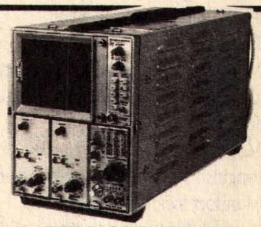

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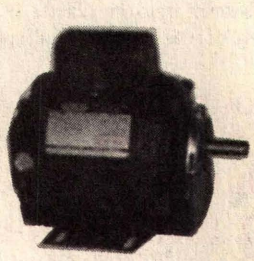
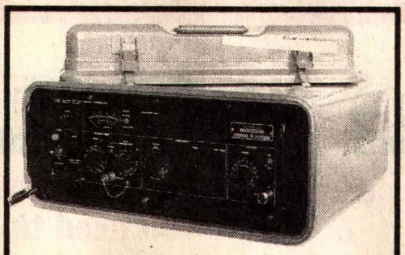


JONES INSTRUMENT TACHOMETER

Centrifugal Mechanical tachometer. Measures RPM scale to 500 RPM. Coupling shaft ⅛". Accessories: various size rubber tipped drive couplings.

New Price: $75.00



HEWLETT PACKARD 8640B-OPT 323 SOLID STATE SIGNAL GENERATOR

(w/o synchronizer) Frequency range: 450 KHz to 512 MHz, to 1100 Mhz with external frequency doubler option supplied. Ten Frequency bands in octave increments from 500 KHz; band 11 for doubler use. Accuracy: 6 digit LED read out. Stability: < 1000 ppm. Output power: −145 dBm to +10 dBm (0.013 V to 2 V) into 50 Ω. Impedance is 50 Ω, VSWR < 2.0 on 2 V and 1 V range < 1.3 on other ranges >. Modulation: Internal AM, FM and PM, external AM, FM and PM. Pulse frequency: 0.05 to 5 kHz. General: Power Requirements: 100, 120, 220, 240 V, 48 hz to 420 hz, 2 amps. Size: 6" (H) × 19" (W) × 13¼" (D). Wt. 60 lbs. Includes ruggedized case and manual.

Price: $795.00

Current Hewlett Packard Prices: $12,050.00

COLLINS HF8050 SOLID STATE SYNTHESIZED RECEIVER

Freq: 250KHZ to 29.99999MHZ; 10HZ steps thumb wheel tuning. Modes: SSB, USB, LSB, CW, AM. B.W.: 2.7KHZ, 16KHZ. Sensitivity: 0.7MV 10dB S+N/N. Computer controllable. Squelch. Power: 103 to 127U, 47 to 63HZ/207 to 253V, 80 watts. Size: 7"H × 19" × 20.9"D. Wt: 42 lbs.

Price: $2500.00

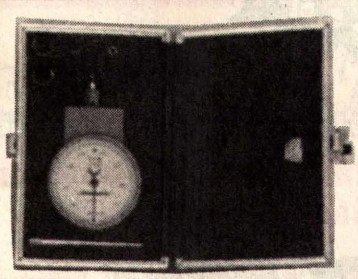
Collins 651S-1 synthesized, solid state HF receiver, AM, CW, SSB, FM, ISB. Freq: 250 KHZ to 29.9999 MHZ. 1MHZ, 0.1 MHZ, 100 CPS steps. IF filters: 16MHZ, 6MHZ, 3MHZ, 2.7 MHZ, 0.5 MHZ, No 0.2. Input power: 115/230v, 47 to 63hz, 70 to 110 watts.

Price: $1,895.00

BIRD ELECTRONIC THRULINE RF COUPLER

Impedance 50.52. Uses standard RF slugs to couple RF out to meter (meter and slugs not supplied). Input.output connectors: type N male and female. Part No: 4230-058

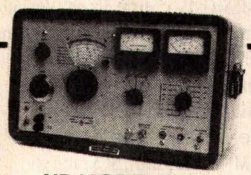
New Price: $85.00



DAYTON CAPACITOR MOTOR

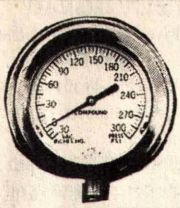
5K504 ½HP capacitor start 1725 RPM 115V, 60HX, 1PH. Sleeve bearings rubber mounted open, driporoof thermal protection nema 56 frame ⅝" dia. shaft 3½" shaft HT.

New Price: $75.00



HP MODEL 606B

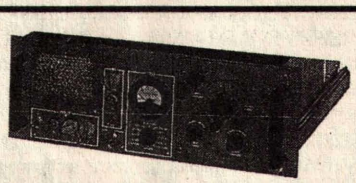
Signal Generator: Later version of 606A. Frequency range of 50 KHz to 65 MHz in size bands; accuracy ±1%. Output level is continuously adjustable from 0.1uV to 3V into 50 resistive load. Modulation level of 0 to 95% on 1V attenuator range and below, 0 to at least 20% on 3V range **Price: $375.00**



GENUINE U.S. NAVY

−30 vacuum to +300 PSI Bronze Encased Gauge. 5¼" diameter ¼" male NPT.

New Price: $85.00



ITT UHF POWER AMPLIFIER AM6155/ GRT-22

Frequency range: 225 MHZ K 399.95MHZ, Power Output: 50 watts. Impedance: 500HMS. Modulation range: 90% ± 10%. Power Req: 105/120V/210/240 at 47 to 420 HZ, 610 watts max. Size: 5¼"H, 17¼"W, 18½"D at 70 lbs.

Price: $300.00

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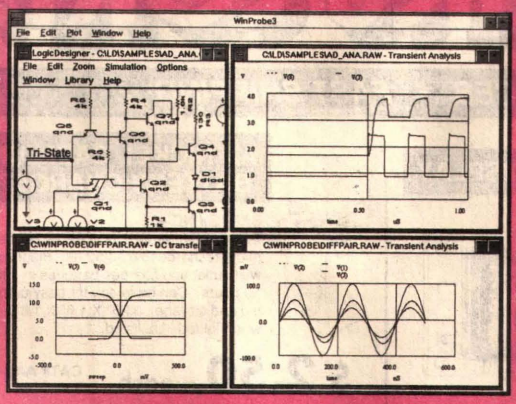
Powerful Integrated Digital and Analog (Berkeley Compatible Spice) Circuit Design and Simulation Software for Microsoft Windows TM (network compatible)

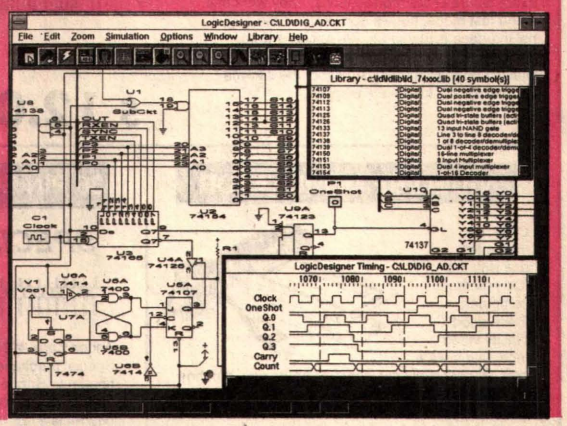
Includes 4 Integrated Modules: LogicDesigner + WinSpice3 + WinProbe3 + SymbolEditor



Comes with a **Spice library plus 5** more libraries of **active** digital devices CMOS, 74xx, 74xxx, ALUs, counters, MUX, FFs etc. **Plus a passive** symbol library of **microprocessors** and more. Use the **symbol library editor** to **design your own symbols** and symbols for subcircuits, true bussing, buss pins can be assigned a unique name, parts billing list, legends, nested **subcircuits** for **hierarchical top down or bottom up design**, checks fan out violation and electronic rules, device unit numbers/chip pinouts automatically added as per data books, spice netlist generation, continuous **zoom** in/out, cut/copy/paste, multiple rotatable fonts, rotatable symbols, multipage zoomed in/out printouts to any windows printer/plotter.

LogicDesigner Digital Simulation/Schematic Capture Module

Interactive digital simulation and schematic capture, with glitch detection, single step mode, variable speed simulation, printable timing diagram output, truth table generation, binary to **7 segment displays**, hex keypads, clock sources, logic probes. Built in **logic analyzer** can be set up to generate **breakpoints** during simulation from user defined AND/OR combinations of circuit signals and **sequential events** to help **debug circuit** timing/logic/race conditions. Simulates tri state, open collector & don't care logic, RAM/ROM, one shot, carry look ahead, shift reg, pull up/down.



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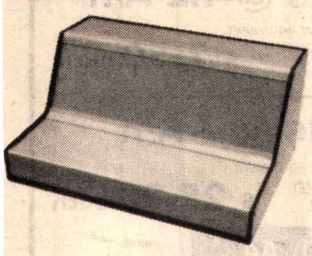
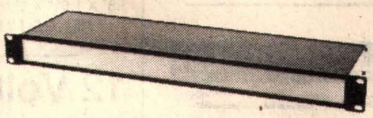
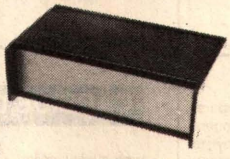




PANELS ARE .063" ALUMINUM

RACK CHASSIS

MODEL	DESCRIPTION W x D x H (inches)	PRICE $
1RU5	19 x 5 x 1.75	30.85
1RU7	19 x 7 x 1.75	33.10
1RU10	19 x 10 x 1.75	35.25
2RU5	19 x 5 x 3.5	33.10
2RU7	19 x 7 x 3.5	35.25
2RU10	19 x 10 x 3.5	37.50
3RU5	19 x 5 x 5.25	41.90
3RU7	19 x 7 x 5.25	44.10
3RU10	19 x 10 x 5.25	46.30



PANELS ARE .063" ALUMINUM

METAL CABINETS

MODEL	DESCRIPTION W x D x H (inches)	PRICE $
MC-1A	4 x 3 x 2	16.50
MC-2A	6 x 3 x 2	18.75
MC-3A	8 x 3 x 2	20.95
MC-4A	4 x 4 x 3	18.75
MC-5A	6 x 4 x 3	20.95
MC-6A	8 x 4 x 3	23.15
MC-7A	4 x 7 x 4	20.95
MC-8A	6 x 7 x 4	23.15
MC-9A	8 x 7 x 4	25.75

PANELS ARE .080" ALUMINUM AND ARE FIELD REMOVABLE

HEAVY DUTY RACK CHASSIS

MODEL	DESCRIPTION W x D x H (inches)	PRICE $
3RU7 HD	19 x 7 x 5.25	115.00
3RU10 HD	19 x 10 x 5.25	121.00
3RU14 HD	19 x 14 x 5.25	134.00
4RU7 HD	19 x 7 x 7.0	121.00
4RU10 HD	19 x 10 x 7.0	129.00
4RU14 HD	19 x 14 x 7.0	136.00
5RU7 HD	19 x 7 x 8.75	126.00
5RU10 HD	19 x 10 x 8.75	133.00
5RU14 HD	19 x 14 x 8.75	143.00

DUAL SLOPE METAL CABINETS

MODEL	DESCRIPTION MAJOR DIM. SECONDARY DIM. W x D x H1 x S1 x S2 x D1 (in.)	PRICE $
DS-1	4 x 6 x 4 x 1.2 x 1.9 x 2.4 x 1.6	59.00
DS-2	6 x 6 x 4 x 1.2 x 1.9 x 2.4 x 1.6	63.25
DS-3	8 x 6 x 4 x 1.2 x 1.9 x 2.4 x 1.6	67.50
DS-4	10 x 6 x 4 x 1.2 x 1.9 x 2.4 x 1.6	71.50
DS-5	12 x 6 x 4 x 1.2 x 1.9 x 2.4 x 1.6	76.00
DS-6	16 x 6 x 4 x 1.2 x 1.9 x 2.4 x 1.6	81.00
DS-7	4 x 8 x 6 x 2 x 3.1 x 3.5 x 1.9	69.00
DS-8	6 x 8 x 6 x 2 x 3.1 x 3.5 x 1.9	73.00
DS-9	8 x 8 x 6 x 2 x 3.1 x 3.5 x 1.9	76.00
DS-10	10 x 8 x 6 x 2 x 3.1 x 3.5 x 1.9	82.75
DS-11	12 x 8 x 6 x 2 x 3.1 x 3.5 x 1.9	87.75
DS-12	16 x 8 x 6 x 2 x 3.1 x 3.5 x 1.9	100.75

EXTRUDED SERIES

MODEL	DESCRIPTION W x D x H (inches)	PRICE $
ET-1	4.52 x 4.35 x 1.57	10.00
ET-1B	4.52 x 4.35 x 1.57	10.00
ET-2	4.52 x 6.00 x 1.57	24.00
ET-2B	4.52 x 6.00 x 1.57	24.00
CCET	PLASTIC CARRYING CASE	18.00

SHEET METAL PUNCHES

MODEL	HOLE SIZE & SHAPE	PRICE $
PUNCH 1	3/8" ROUND	9.95
PUNCH 2	7/16" ROUND	9.95
PUNCH 3	1/2" ROUND	9.95
PUNCH 4	9/16" ROUND	12.95
PUNCH 5	5/8" ROUND	12.95
PUNCH 6	11/16" ROUND	12.95
PUNCH 7	3/4" ROUND	12.95
PUNCH 8	13/16" ROUND	12.95
PUNCH 9	7/8" ROUND	12.95
PUNCH 10	1" ROUND	13.95
PUNCH 11	1-1/16" ROUND	13.95
PUNCH 12	1-1/8" ROUND	13.95
PUNCH 13	1-3/16" ROUND	13.95
PUNCH 14	1-1/4" ROUND	14.95
PUNCH 15	1-3/8" ROUND	14.95
PUNCH 16	1-1/2" ROUND	16.95
PUNCH 17	1-5/8" ROUND	21.95
PUNCH 18	1-3/4" ROUND	24.95
PUNCH 19	2-5/8" ROUND	61.95
PUNCH 20	11/16" SQUARE	32.95
PUNCH 21	3/4" SQUARE	36.95
PUNCH 22	1" SQUARE	46.95
PUNCH 23	21/32" x 15/16" RECT.	46.95
*PUNCH 24	*THURST RACES	10.95

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HAND TOOLS

MODEL	DESCRIPTION	RANGE (mm)	PRICE $
MD-1	MICRO REAMER	1.0-5.5	16.50
MD-2	REGULAR REAMER	3.0-12.0	26.00
MD-3	LARGE REAMER	10.0-25.0	48.00
RT-1	RETHREADER	3.0 x 0.5	10.50
AD-1	DRILL BIT ADAPTER FOR POWER SCREWDRIVER		6.50

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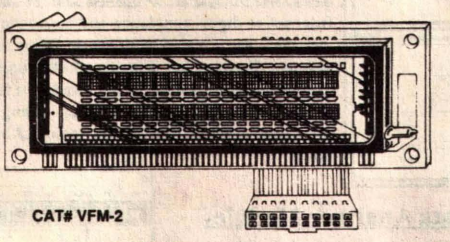
VACUUM FLUORESCENT DISPLAY

Futaba # M202SD08GL
Two rows of 20 characters displayed in a 5 X 7 dot matrix. Bright green 5 mm X 3.5mm characters. On board CPU, driver and DC-DC converter simplifies hook-up and interfacing. Operates on 5 Vdc. Displays 215 different characters including alphanumeric and other symbols. ASCII configuration. Module overall dimensions: 6.1" X 1.7" X 0.7" thick.

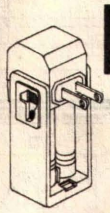
These displays were modified somewhat from original specifications and we do not know the exact nature of the modifications. They work fine in the test mode, but we don't know if the original interface is the same. We supply a data/hook-up sheet for the pre-modified device which, hopefully, provides most of the information necessary to use the display.



CAT# VFM-2

$ 12.00 each

AA NICKEL CADMIUM BATTERY CHARGER



SANYO# NC-452
Battery charger for 2 or 4 AA nickel cadmium rechargeable batteries. Plugs into wall outlet and charges batteries in 8 to 10 hours. Can be folded for easy carrying and storage. 3.25" X 1.6" X 1.81" when folded. UL listed.

$ 2.50 each CAT# AAC-1

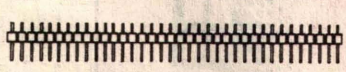
VIDEO/RF MODULATOR

Originally made for use with the Commodore computer, these good quality video modulators were probably originally designed for 9 Vdc use, but they operate well on 6-12 Vdc. They accept color video and audio, and a selector switch is provided for output to channel 3 or 4. Easy to hook-up. Requires a 6-12 Vdc power supply or wall transformer and a connector to interface with your audio/video source. Output is an RCA jack. Hook-up instructions included. 3" X 1.47" X 0.75".

$ 5.00 each CAT# AVMOD-3

36 PIN SNAPPABLE HEADER

SPECIAL! SPECIAL!



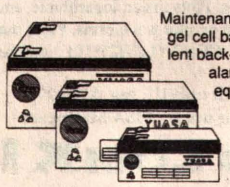
Arkles Corp. # 25MSS2A36GG030
Special purchase of 36 pin, single row 0.1" spacing headers. Snappable to smaller lengths. Sold only in bags of 100 pieces. Our regular price on a 40 pin header is $120.00 per 100 pieces.

CAT# SHS-36

$40.00 for 100 piece bag

$350.00 for 1000 pieces

RECHARGEABLE GEL CELL BATTERIES



Maintenance free, rechargeable gel cell batteries are an excellent back-up power source for alarms, communications equipment, lighting or computers. They can be used in any position and can be trickle charged for long periods of time. These were removed from new equipment and are guaranteed functional.

6 Volts @ 4 A/h

Panasonic # LCR6V4P or equivalent.
2.75" X 1.87" X 4" high.

CAT# GC-64 **$ 12.00** each

12 Volts @ 1.2 A/h

Yuasa # NP1.2-12 or equivalent.
3.8" X 1.81" X 2" high.

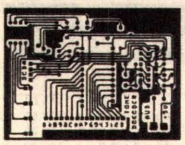
CAT# GC-1212 **$ 7.50** each

12 Volts @ 7 A/h

Yuasa # NP7-12 or equivalent.
3.8" X 1.81" X 2" high.

CAT# GC-127 **$ 25.00** each

Make PC Boards in Minutes...



Five 8 1/2" X 11" sheets and instructions.

$11.95 per pack

Prototypers, developers and hobbyists can now make PC boards direct from CAD, PCB layout systems or magazines using a photocopier, or laser printer. Techniks Inc's new "Press-n-Peel" copy paper allows you to photocopy PC artwork and iron it on to copper-clad board. It can then be chemically etched in the usual fashion. The process is so easy and fast you won't believe it.

CAT# TEK-5

CARBIDE DRILL BITS (USED)

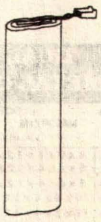
High quality, solid carbide drill bits with 1/8" shanks. Ideal for precision drilling. These bits were used in PC board manufacturing and were routinely removed from service while they still had lots of life in them. Available in the following sizes:

#	SIZE (")	CAT#
63	0.037	DRB-63
61	0.039	DRB-61
59	0.041	DRB-59
58	0.043	DRB-58
57	0.045	DRB-57
56	0.046	DRB-56

Minimum Purchase 10 Pieces Of One Size

10 of one size $ 5.00
50 of one size $ 20.00

4 (USED) AA RECHARGEABLE BATTERIES



Battery pack with 4 AA nickel-cad batteries in series to make a 4.8 volt pack. Batteries have solder tabs and can be separated and reconfigured.

$ 2.00 per pack CAT# NCB-41AAU

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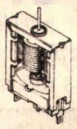
1.5 - 4.5 Volt



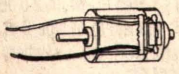
Mabuchi
Approx. 9000 RPM @ 3 Vdc.
Rectangular shape
0.71" X 0.75" X 0.38".
Shaft size 0.06" dia. X 0.27" long.
Solder loop terminals.

CAT# DCM-45

3 for $1.00

100 for $25.00 • 1600 for $320.00

1.5 - 3 Volt



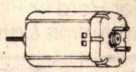
Mabuchi
Approx. 9000 RPM @
1.5 Vdc. Modified oval
shape 1.15" long X
0.78" X 0.85". Shaft size:
0.08" dia. X 0.60" long. Pigtail leads.

CAT# DCM-46

3 for $1.00

100 for $30.00 • 1000 for $250.00

1.5 - 3 Volt



Johnson Motors # NF213G-2050
Operates well at 1.5 vdc to 4.5 Vdc.
0.72" X 0.94" X 1.38" long.
0.08" (2mm) diameter shaft is
0.25" long.

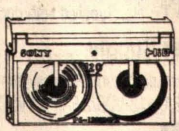
CAT # DCM-42

3 for $ 1.00

150 for $45.00 (30¢ea.)
600 for $150.00 (25¢ ea.)

8 mm Video Camcorder Users!

(USED) "HI-8" VIDEO CASSETTE

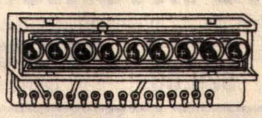


We have a new supply of these popular T-120 (120 minute) Hi-8 video cassettes. These are top quality, metal oxide (particle) cassettes that were used for a short time, then bulk-erased. Each cassette has its own plastic storage box. New, they would sell for considerably more than we're asking. We've sold thousands, and our customers love them.

10 for $28.00 **$3.00 each**

CAT# VCU-8

9 DIGIT LED DISPLAY



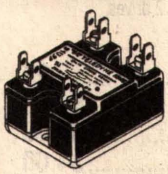
National Semiconductor # WUS2294V-0 (NSA1198)
9 seven segment red LED characters, each is 3 mm high. Mounted on a module 2" X 0.73" X 0.23".
Common cathode. Includes hook-up diagram.

CAT # TDY-9

$ 1.25 each

10 for $10.00

10 AMP SOLID STATE RELAY



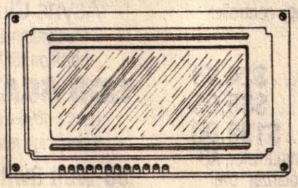
Teledyne Relays # 615-8500
Control Voltage: 3-32 Vdc
Load: 10 amp,
250 Vac 50/60 hz.
Standard "hockey puck" size: 2.27" X 1.72" X 0.95".
Screw and qc terminals.
UL and CSA listed.

CAT # SSRLY-14

$ 10.50 each

10 for $95.00

240 X 128 DOT LCD

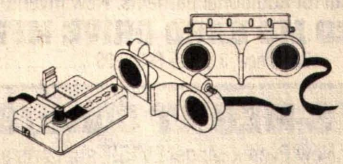


Optrex# DMF660N-S 240 X 128 dot LCD module with on-board dnvers. Will display graphics, figures and characters. Module size: 5.68" X 4.1" X 0.5" thick. Viewing area: 4.1" X 2.52". Dot size: 0.4mm X 0.4mm. High contrast, wide viewing angle. Low voltage drive and low power consumption. Uses fitting controllers LSIMSM6255, HD64646, SED1330, SED1351. Includes hook-up instructions and specs.

CAT# LCD-15

$29.95 each

ULTRASONIC PROXIMITY DETECTOR



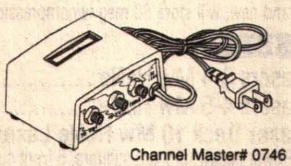
The ED-100 was designed for use as an auto/RV/truck back-up alarm. Two 40 khz ultrasonic emitter/detector modules attach to the back of the vehicle and warn the driver when the rear of the vehicle is within 24 feet of another object. A digital display and audible beeper inside the car continually monitor the distance to impact. The ultrasonic modules measure 5.81" long X 1.9" wide X 2.05". Operates on 12 or 24 Vdc Includes instructions for installation. The units are new, in original cartons and, as far as we know, in working condition. The company that marketed this device is no longer in business, and no manufacturer's guarantee is in effect. **We offer these ultrasonic detectors for experimentation only, and in no way wish to promote their usefulness as a driving aid.**

Original Sold For OVER $100.00.

$ 24.95 each

CAT # ED-100

EXPERIMENTER'S DELIGHT VHF TO UHF BLOCK CONVERTER



Channel Master# 0746

This is one of those deals that's too good to be true. Brand new, in the box, Channel Master block converters. They used to be popular a few years ago before there were a lot of cable-ready TVs. Somewhere in the world we know there is still a demand for them- especially at this price. Designed to convert television VHF channels 2 through 13 and A through W to UHF channels 36 through 76. The box alone, is a great project box. The 10 ft. AC power cord, the interior components, F connectors and AC receptacles are well worth the price.

CAT# CM-0746

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FLOPPY DRIVE New, 360K DSDD $9.95
Specify black or beige bezel

XT Motherboard 8 Slots, 8 MHz, ... $16.95

FLOPPY DRIVE CONTROLLER $21.49
1.44MB/1.2MB/720KB/360KB FDC (for 8088, 286, 386).
These will fit in XT as well as faster machines. They control 2 drives.

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8751H	$8.00
8749	$4.00
8031	$2.00

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2764	.99
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27256	$3.00
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IC MEMORY CARD $99.00
Buffalo RJB-1000, SCRAM card - 1 Meg PC-MCIA 2.0 JEIDA SCRAM Memory Card by Melco Inc. Type 1 card, thinnest to fit type 2 or 3 slots. Will fit device meeting standard: HP95LX, Sharp, NCR, etc. Elsewhere for $150. Our price is ***BELOW WHOLESALE!***

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Complete package includes cash drawer, controller board, and free POS software

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Brand new, will store 80 meg w/compression, interface to floppy controller

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★ **Laser Deck 10 Mw HeNe Laser** $199.00
Power supply, 2 beam splitters, 5 front surface mirrors, AO modulator, AO driver, polygon scanner, photo detectors, 3 special lenses, polarizer, over $5,000 worth of optical components plus documentation. Sold many of these to Fortune 500 companies, universities, and research labs. Applications include research, design and engineering. An experimenter's dream.

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Laser Diode $15.00
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Laser Diode Kit $49.00
To power TOLD9200, includes laser diode, board, parts, instructions

Laser Tubes $39.95
From SIEMENS, brand new, 5mW HeNe

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MOS Fet N-Channel Part #SGSP222 50V 10A ... 4/$1.00

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Token Ring Board $99.00
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MFM, WD1002-WA2 ..... $19.95

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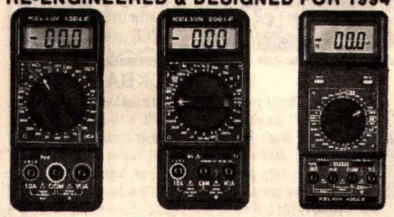

150 LE - *Student* 200 LE - *Technician* 400 LE - *Engineer*

Standard Features - ● AC & DC VOLTAGES ● DC CURRENT ● RESISTANCE ● **TRANSISTOR** ● CONTINUITY TEST - Buzzer ● DIODE TEST ● 3 1/2 Digit LCD ● 10M ohm INPUT IMPEDANCE

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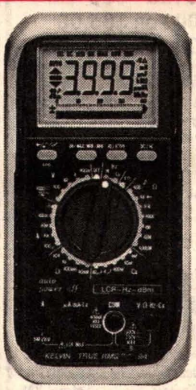
BATTERY TEST TRANSISTOR **DC CURRENT** 10 Amp	**FREQ COUNTER** up to 20MHz **TRANSISTOR** **CAPACITANCE** from 1pF to 20uF **AC/DC CURRENT** 10 Amp	**INDUCTANCE** Resolution 1uH **FREQ COUNTER** up to 20MHz **CAPACITANCE** from 1pF to 200uF **AC/DC CURRENT** **DUTY %** 20 Amp
Stock # 990122	Stock # 990123	Stock # 990124
$29.95	$49.95	$79.95

Designed to meet IEC-348 & UL-1244 safety specifications

2 Year Warranty *(Parts & Labor)*



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Popular Electronics
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$199.95
*See Standard Features Listed below

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**** Standard Features - Models 94 & 95***

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- ● OHM METER ● DATA HOLD ● RELATIVE MODE
- ● FREQ COUNTER to 4 MHz (Model 95)
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- ● MAX/MIN AVERAGE MEMORY RECORD
- ● 10A HIGH-ENERGY FUSE PROTECTION
- ● AUTO SLEEP & AUTO POWER OFF

KELVIN 100 Basic

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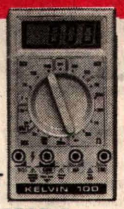

- ● AC & DC VOLTAGES
- ● DC CURRENT
- ● RESISTANCE
- ● CONTINUITY TEST-Buzzer
- ● 3 1/2 Digit LCD
- ● LOW BATTERY INDICATOR
- ● DIODE TEST ● BATTERY TEST

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250 LE
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- ● ACCURACY: 0.5%
- ● **RANGES**:20mF, 2000uF, 200uF, 20uF, 2uF, 200nF, 20nF, 2000pF, 200pF
- ● Zero Adjust
- ● Safety Test Leads
- ● Test Socket for Plug-in Components

AUTO-RANGE METER

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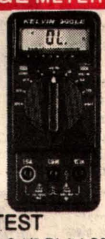
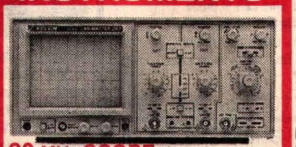
AUTO-RANGE



- ● ACV & DCV
- ● DC CURRENT
- ● RESISTANCE
- ● CONTINUITY TEST
- ● DIODE TEST 3 1/2 Digit LCD
- ● 10M ohm INPUT IMPEDANCE

INSTRUMENTS



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Dual Trace 2 Yr Warranty-Parts & Labor
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Dual Trace with Delayed Sweep
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990105	RED	$.65 ea.	$.50 ea

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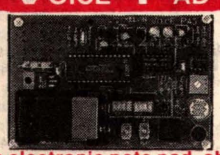

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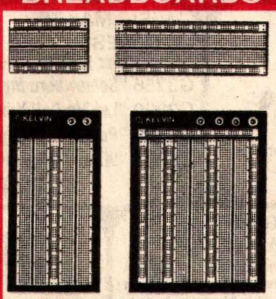
BREADBOARDS



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680097	0	840	$ 5.95
680098	2	1380	$11.75
680100	4	2390	$22.95

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600029	**556 DUAL TIMER**	$.40 ea
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600018	**741C OP-AMP** INTERNALLY COMPENSATED	$.30 ea
600026	**1458 OP-AMP** DUAL 741C OP-AMP	$.35 ea
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630383	**PN2222**	$.08 ea
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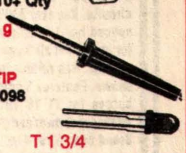

LED T 1 3/4

Stock No.	Color	100+ Qty	1000+ Qty
260020	RED	$.05 ea	$.045 ea
260027	GREEN	$.08 ea	$.07 ea
260026	YELLOW	$.08 ea	$.07 ea
260078	2 COLOR RED/GREEN	$.32 ea	$.29 ea

XENON STROBE TUBE
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for XenonStrobe Tube
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IR Pair, LED infrared transmitter and receiver
Stock No. 260061
$1.95 ea

NEON LAMP
NE2, 2" Lead
Stock No. 260003
$.15 ea
$ .12 ea / 100+ Qty

PHOTO CELL
Photo Cell - 450 ohm
Stock No. 260017
$.65 ea $.45 ea /20+ Qty
Photo Cell - 1.5K ohm
Stock No. 260018
$.65 ea $.45 ea /20+ Qty

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PUSH-ON, PUSH-OFF
Stock No. 270021
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SUB-MINIATURE MOMENTARY SWITCH
Stock No. 990002
$.35 ea
$.28 ea / 100+ Qty

MINIATURE TOGGLE SWITCH
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$.90 ea Type - SPST
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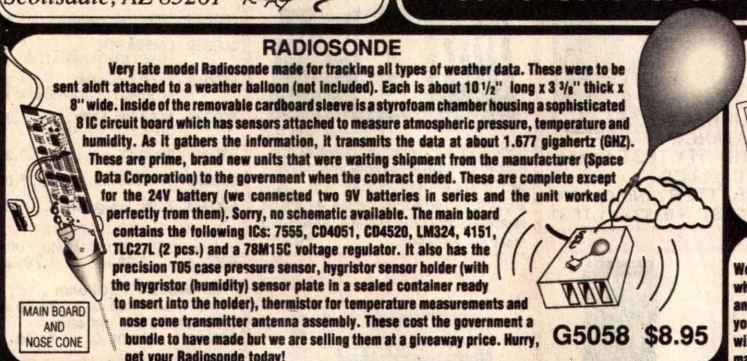
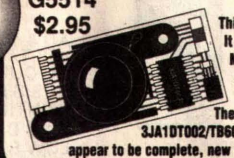


Very late model Radiosonde made for tracking all types of weather data. These were to be sent aloft attached to a weather balloon (not included). Each is about 10 1/2" long x 3 3/8" thick x 8" wide. Inside of the removable cardboard sleeve is a styrofoam chamber housing a sophisticated 8 IC circuit board which has sensors attached to measure atmospheric pressure, temperature and humidity. As it gathers the information, it transmits the data at about 1.677 gigahertz (GHZ). These are prime, brand new units that were waiting shipment from the manufacturer (Space Data Corporation) to the government when the contract ended. These are complete except for the 24V battery (we connected two 9V batteries in series and the unit worked perfectly from them). Sorry, no schematic available. The main board contains the following ICs: 7555, CD4051, CD4520, LM324, 4151, TLC27L (2 pcs.) and a 78M15C voltage regulator. It also has the precision T05 case pressure sensor, hygristor sensor holder (with the hygristor (humidity) sensor plate in a sealed container ready to insert into the holder), thermistor for temperature measurements and nose cone transmitter antenna assembly. These cost the government a bundle to have made but we are selling them at a giveaway price. Hurry, get your Radiosonde today!

G5058 $8.95

G5514 $2.95 TINY TRACKBALL



This is probably the tiniest trackball ever made! It measures only 1 11/16"L x 13/16"W x 3/8"H. Made by Alps for a major laptop computer maker that went out of business. They are very precision made and highest quality. The components are all SMD with an IC marked 3JA1DT002/TB6012CF and a tiny 8 position connector. They appear to be complete, new and very recent in manufacture. We have no hookup info or schematic. Hurry, these may not last long!

HANDBOOK OF KIT PLANS

We have a limited supply of the *1991 Electronic Hobbyist Handbook* which features the complete Plans, Parts Lists, PC Board Layouts and Assembly Instructions for 31 of our most popular kits. Allows you to find out detailed information on many of our kits. Build them with your parts or buy the kit from us. This handy 100 page magazine also contains information on how to read resistor color codes, identify kit components, etc. Contains articles on Geigers, Amps, Sequencers, Alarms, etc.

G2710 $3.50

RADIOSONDE MAIN CIRCUIT BOARD

G5064 $1.95

Main circuit board as used in the Radiosonde above. These are the "Heart" of the Radiosonde and contain the following ICs; 7555, CD4051, CD4520, LM324, 4151, TLC27L (2 pcs) and a 78M15C voltage regulator. It also contains the expensive atmospheric pressure sensor made by SDC. The boards are brand new and were in the final assembly stage - they do not come with the transmitter nose cone, humidity sensor or the thermistor. They do have various resistors, tantalum caps, regular caps, trimmer resistors, etc. Size: 6 1/2" x 2". Brand New Prime - No specs or schematics.

SUPER INFRARED LED

Super output jumbo size infrared LED made for use in Zenith remote controls. Diffused grayish blue lens. High output unit actually produces 2 spots of infrared energy.

G2318 3/$1.00
100/$25.00
1000/$220.00

CP CLARE 5VDC DIP RELAY PRMA 100375

Small reed relay in a miniature blue epoxy package features 1 form A (SPST) contacts rated 1amp. Coil voltage 5VDC resistance 380 ohms. Fits in standard 14 pin IC socket.

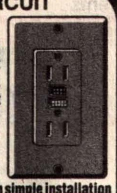
G5108 89¢ EA.
100 FOR $85.00
1000 FOR $750.00

VECTOR PADBORD TYPE 3677-6

Very useful Vector glass epoxy circuit board for prototyping various circuits. Has over 3300 drilled holes spaced on .1" centers. Very useful for laying out all types of electronic circuits. Has various foil patterns as shown. Features 3 hole solder pads, busses for 21 16 pin dip devices interposed power and ground busses. Brand new. Size: 4 1/2" x 8 1/16".

G5050 $8.00

GROUND FAULT CIRCUIT INTERRUPTER (GFCI)



This quality GFCI is the same type found in many new homes all over the country. It features trip time in .025 seconds for 240mA fault, silver alloy contacts, tough impact resistant construction and trip threshold of only 5mA (± 1mA). This GFCI is brand new, grey in color and mounts in a standard wall outlet. Complete with all hardware and wall plate. Leviton# 6599-GY. Brand new in box with simple installation instructions.

G5007 $9.95

SHARP GP1U5 INFRARED MODULE

Super sensitive infrared module by sharp is only 3/8" x 5/8" x 1/2". Turns on any LED or low voltage relay from over 50 ft. away when you press buttons on almost any infrared TV or VCR remote controller. Has only 3 hookup pins and operates from 5 to 9VDC. Module and simple hookup diagram.

G5076 $1.49 EA. • 10/$14.00
100/$125.00 • 1000/$1180.00

INVERTER TRANSFORMERS 4 LEAD TRANSFORMERS

These convert low voltage DC to high voltage required for strobes, Geiger counters, fluorescent displays, etc. when used in conjunction with a 555 IC oscillator circuit (schematic supplied).

Stock#	Size	Price
N1703	.4" x .4" Tiny	$2.00
G993	.5" x .5" Medium	$1.75

BLUE T1 3/4 JUMBO LED

Factory fresh T1 3/4 Blue LED features clear lens and long leads. We purchased these directly from the factory and are offering them to you at close to our cost to provide you with a new dimension for your projects. The blue LED is made from silicon carbide and can withstand up to 50mA current without damage. We have found that it looks best if operated close to a 4VDC limit. Very unique and colorful!

G5067 79¢
10 FOR $7.50 • 100 FOR $69.00

TRANSISTORS BY THE SCOOP

We just purchased close to a 1/2 million prime house numbered transistors made for an OEM. Each is house numbered and has full length leads. They are absolutely first quality - not rejects. We think there are FETs, Darlingtons and small signal NPN transistors. We do know that there is at least 4 different house numbers. Most are regular size T092 cases however, there are also a few 1 watt T092 cases. Tremendous value as we are selling them by the scoop. Each scoop holds at least 500 transistors!

G5071 1 SCOOP $5.00
10 SCOOPS (ABOUT 5,000) $40.00

HIGH BRIGHTNESS ALL COLOR LED ASSORTMENT

Assortment of 2 of each of the Red, Yellow and Green LEDs advertised at right. You get 6 LEDs total.

G5464 $1.00

STANLEY HIGH BRIGHTNESS CLEAR CASE LEDS

Powerful bright LEDs in popular T1 3/4 case. Each has a water clear lens and long leads.

RED	G5307	10/$1.00	100/$8.00
GREEN	G5308	8/$1.00	100/$9.00
YELLOW	G5309	8/$1.00	100/$9.00

10" THRUSTER WOOFER

You will be amazed at the great sound of this high quality 10" woofer that is perfect for upgrading your old system or new construction. We were told these were made by JBL (their model #210H). They feature 8 ohm impedance, poly foam surround and a frequency response from 25KZ to 2KHZ. Weight: 2.5 lbs. Brand new and at an incredible blowout price!!!

G3311 $15.95 EA.
OR
PAIR FOR 30.00
(INCLUDE $5.00 S&H)

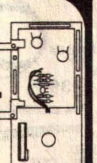
WOW!

SUPER PC DRILL BIT ASSORTMENT

Perfect assortment for PC board needs. Eight different drill bits ranging from small to large sizes.

G590 $6.95

MUSIC MAKER MODULES



Operate on 6VDC to 12VDC with built in speaker.

G3256 "Somewhere My Love"
G3900 "Let Me Call You Sweetheart"
G3226 "Pomp and Circumstance"
G5034 "Winter Wonderland"

$1.00 EACH

WEIRD GENERATOR/ LINEAR MOVER

Unique science item consists of a large coil which slides between two sets of rare earth super magnets. The coil has 2 mounting holes to attach anything you want and it travels to the end very rapidly when 12VDC is applied to it. Reverse the voltage and it snaps back to the other end. It also can generate enough electricity to light a LED. Simply solder any LED to the coil and as you shake the coil back and forth the LED will light up. Unusual item is about 3 3/8" l x 1 3/4" H x 7/8" W. Removed from optical hard drives for Next Computers.

G3909 $10.00

µLYNX TRACKBALL

MicroLynx trackball made by Honeywell for XT IBM compatible computers with MS-DOS up to version 3.0. These feature easy installation as it connects between your keyboard and your computer so no serial I/O card is needed. Features graphics driver, ergonomic design, self contained menu for user programming of ball and button definitions, text and graphics modes, fast direct cursor motion, etc. Comes complete with cable, instruction manual, software on 5 1/4" floppy. Brand new in boxes. NOTE: For XT computers only! Blowout Price:

G3649 $4.50

SUPER PC BOARD BLOWOUT

This is your chance to stock up on prime copper clad for making all types of custom PC boards. Various sizes: 2" x 7" up to 6" x 6" or larger. This is high quality glass epoxy double sided copper clad!

G3500 50/$7.95
(Add an additional $2.00 extra heavy shipping)

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MINI TVT	$45	DMTB	DISCONTINUED
TBD-P (PINK)	DISCONTINUED	SB-3 (REFURB.)	$29

SCIENTIFIC ATLANTA

SA-3 ..... $49
SA-DF W/SWITCH $75

PIONEER

GREEN $89

Converters

PANASONIC	TZPC-1453G2
JERROLD	DQN-7, DQN-5
SCIENTIFIC ATLANTA	8511,8529

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SA 8580 6-BUTTON	$17.50
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ZENITH 3-WIRE CHIP	$11.00

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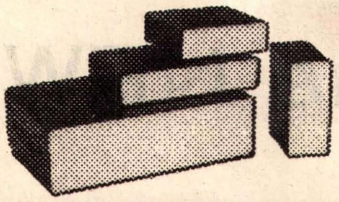
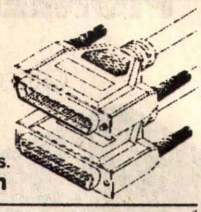


STEEL ENCLOSURES

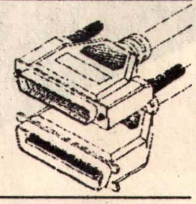
Features include ventilation holes, self-adhesive rubber feet. Front and real panels are 0.05" aluminum alodine painted white. Top and bottom covers are 0.04" phosphated steel painted black.

E3119A (2.5" x 8" x 7")	**$12.95**
E3119B (2.5" x 12" x 7")	**15.95**
E3119F (2.5" x 17" x 11")	**19.95**
E3119G (3.5" x 8" x 7")	**13.95**
E3119K (3.5" x 17" x 11")	**24.95**
E3119P (5.2" x 17" x 11")	**29.95**



DB25 MALE TO FEMALE CABLE

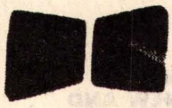
Hi-quality molded ends. (94W006) **$5.95 each**



PARALLEL PRINTER CABLE

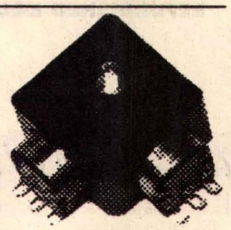
PC-compatible. High-quality molded ends.

- **3-Ft.** (94W006) **$2.89 each**
- **6-Ft.** (94W007) **$3.29 each**



NEODYMIUM MAGNETS

100+ Gauss each. (92N003) **6 for $9.95**



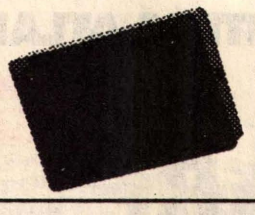
JOYSTICKS

Base 1" x 1" x 1". Well-constructed.

- Two 5K pots. (93P004) **$3.95**
- Two 150K pots. (93P005) **$3.95**

SCANNER RF AMPLIFIER

5 MHz to 900 MHz installs at antenna and serves as a preamplifier to increase signal to noise ratio. Increase the sensitivity of your scanner or shortwave receiver over six times (10 dB gain). Easy hookup. Power supply and coupler included. (92A025) **$19.95 each**



AMAREX UNIBOX

2" x 2.5" x 0.75", with 0.125" hole in one end. (92U065) **Three for $5.00**

STEREO EARPHONES

Unit impedance 32Ω ± 1.5%; 27mm mylar speakers with washable ear sponge; max. power 0.05W; 4-foot cord; compatible with all personal stereo products. (93V002) **$3.95 each**

PLUG-IN POWER SUPPLY

12VDC @ 0.8A. CIE #DV-1280. (93E009) **$4.95 each**

3-SECTION DIELECTRIC FILTERS

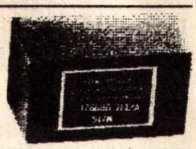
- 1875 MHz. Matsushita #GPS1575. (93P013) **$9.95 each**
- 1226 MHz. Matsushita #GPS1226. (93P014) **$9.95 each**

15KV TRANSMITTING CAPS

10 pF (94P009) • 25 pF (94P010)
50 pF (94P011)
Your Choice - $12.50 Each

20 WATT, 50 OHM STRIPLINE RESISTOR

(92P003) **$9.95 each**

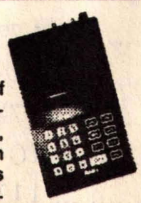


6-POLE LINEAR PHASE FILTER

10.7 MHz. Phase Linear #517N. (94P012) **$11.95**

BRAND "X" LENS

Eyepiece-type magnifier. Focal length = 50mm, f:3.2. Approx. dimensions: dia. = 38mm, length = 43mm. Excellent hand magnifier at approx. two power. (93L009) **$9.95 each**



PAY RADIO DECODER (CODART)

Pay radio? That's right. Part of a system that broadcast purchased programs late at night, these Codart units would turn on one of two tape recorders when a coded tone was broadcast. Contains a Z-80 with 4K of EPROM, 2K of battery-backed up RAM, 18-key keyboard, 8-digit display and relays for the recorders. Reprogram it to make your own stereo or lamp timer, or a time lock to keep the kids from watching too much TV. With documents. (92C002) **2 for $19.95**

TELETEXT DECODER

Teletext signals may be hidden in the TV signal you receive. The VBI-1 decodes the wealth of data at baseband level and converts it to channel 3 for reinsertion into your TV. Teletext messages may be watched superimposed over your favorite TV show. New. (94V002) **$89.95 each**

TELETEXT DECODER CARD

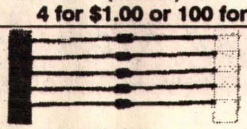
For the first time, the TeleText Decoder card lets you use your personal computer to receive news, sports, stock, traffic and other important news information through normal commercial, cable or satellite TV signals. Without the need and expense of modems, telephone lines or service fees, TeleText offers PC users the ability to view, capture, store and print TeleText information pages easily and quickly.

By simply connecting the TeleText Decoder card to a conventional TV antenna, cable hookup or satellite receiver and tuning in to a TeleText service TV channel, you can receive any TeleText information in full color and graphics. With additional software, you can even capture and manipulate stocks, mutual funds and money market funds for your own personal use. You can also watch regular TV programs with the built-in TV tuner together with a TV display card or by using an additional TV monitor.

For IBM PC, XT, AT or compatible computers, MS DOS 2.11 or higher. 512K memory required. VGA, CGA or EGA display recommended. (94C001) **$199.00 each**

28V MINIATURE LAMP

40mA, 6" wire leads. (92L029) **4 for $1.00 or 100 for $19.95**



12V ±5% 1W ZENER

RD12F. (93S031) **5 for $1.00**

QUACK MEDICINE?

These units are the heart of devices billed as "muscle stimulators" and marketed in the $200 price range. They run on a 9V battery with a 90V pulse output at the rate of approx. one per second. Assembled on a breadboard, components include a timer chip driver transistor and output transformer. Sneak one into biology labs and make a dead frog's legs kick. (94U002) **$4.95 each - 3 for $10.00**

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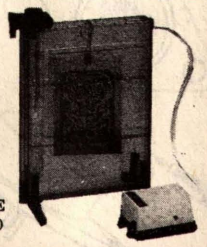
Circuit Specialists, Inc.

We've been providing electronic equipment and supplies since 1971!

Etching Tank



This attractive injection moulded designed tank is ideal for etching your PCBs. It includes a thermostatically controlled glass heater, electric agitator and PCB hanging accessories. Measuring graduations are included. Maximum PCB size is 160mm x 250mm or 200mm x 250mm w/o heater. Typical etching time is 4 minutes.

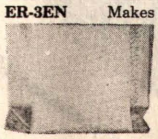
CAT NO	DESCRIPTION	PRICE
ET10EN	Etch Tank System	$48.00

Etching Chemicals

Ferric Chloride

A dry concentrate that mixes with water to make 1 pint of etchant, enough to etch 400 sq. inches of 1oz board.

CAT NO	DESCRIPTION	PRICE EACH 1	5
ER-3EN	Makes 1 pint	$3.50	$2.75



Developer

This product is used as the developer on our positive photo-resist printed circuit boards. Includes instructions. 50 gram package, mixes with water, makes 1 quart.

CAT NO	DESCRIPTION	PRICE EACH 1	10	25
POSDEVEN	Positive Developer	$ .95	$ .80	$ .50

Positive Photo Resist Pre-Sensitized Printed Circuit Boards

These pre-sensitized printed circuit boards are ideal for small production runs. They provide high resolution and excellent line width control. High sensitive positive resist coated on 1oz. copper foil allows you to go direct from your computer plot or art work layout. No need to reverse art.

Single-Sided, 1oz. Copper Foil on Paper Phenolic Substrate

CAT NO	DESCRIPTION	PRICE EACH 1	10	50
PP101EN	100mm x 150mm/3.91" x 5.91"	$2.55	$1.90	$1.70
PP114EN	114mm x 185mm/4.49" x 7.28"	2.98	2.45	1.98
PP152EN	150mm x 250mm/5.91" x 9.84"	5.40	3.98	3.60
PP153EN	150mm x 300mm/5.91" x 11.81"	6.15	4.48	4.10

Single-Sided, 1oz. Copper Foil on Fiberglass Substrate

CAT NO	DESCRIPTION	PRICE EACH 1	10	50
GS101EN	100mm x 150mm/3.91" x 5.91"	$ 3.90	$2.98	$2.60
GS114EN	114mm x 185mm/4.49" x 7.28"	4.80	3.49	3.20
GS152EN	150mm x 250mm/5.91" x 9.84"	8.69	5.98	5.78
GS153EN	150mm x 300mm/5.91" x 11.81"	10.20	7.20	6.80

Double-Sided, 1oz. Copper Foil on Fiberglass Substrate

CAT NO	DESCRIPTION	PRICE EACH 1	10	50
GD101EN	100mm x 150mm/3.91" x 5.91"	$ 5.07	$3.68	$3.38
GD114EN	114mm x 185mm/4.49" x 7.28"	5.95	4.29	3.99
GD152EN	150mm x 250mm/5.91" x 9.84"	10.47	7.39	6.98
GD153EN	150mm x 300mm/5.91" x 11.81"	11.95	8.69	8.30

486 CPU Cooler

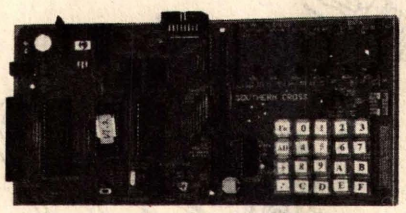
Increase Performance! Prolong Life!

COOL IT! With our easy to install miniature CPU Cooler Fan. This kit includes an omni-directional heat sink, long-life, low noise, DC fan with ready to go power hook-up. The best low-cost, high add-on value investment you can make! PERFORMANCE Typical 80486-33MHz CPU surface temperature reduces from approximately 79°C to approximately 48°C. Typical 80486-50MHz CPU surface temperature reduces from approximately 95°C to approximately 54°C.

	PRICE 1	5
CSI PART# CC-M3EN	$15.95	$14.95

Want More Info on the Southern Cross?

Use our FaxBack Automated Document Retrieval System. Dial 1-800-662-5426 (602-834-1005 in AZ) and select document #5025 on your push-button phone. You'll receive an article reprint from Australia's "Silicon Chip" magazine, reviewing the Southern Cross SBC. This is a free service available 24-hours a day. Don't forget to have your FAX# handy.



THE SOUTHERN CROSS

A Single Board Z-80-Based Computer

Here is a single board computer designed especially for the 1990's generation of students. With a series of add-on boards, smart sockets, fully commented monitor & an intelligent EPROM emulator, it can teach many aspects of micro-processor & micro-controller techniques of programming.

The Southern Cross SBC is designed to teach beginners modern code development techniques as well as assembly language. Start with machine language using the on-board 21 hex digit keypad, then progress to using a PC Assembler provided with many program examples. Serial download assembled program from PC to Southern Cross. Serial interface provided.

Simple, but powerful monitor program fully annotated. Learn to use parts of it in your own programs by 'system calls' & using a 'header file'.

Learn how to single step through your program to find errors. Both hardware & software single stepping provided & explained.

We do not fill the User Manual with pages of theory. Go straight to program examples. Starts from a very basic level anyone can follow.

The Southern Cross system includes:

- All CMOS IC's
- Hardware speed control
- 8K EPROM
- 64K RAM
- 4.00MHz Z80
- 10 year RAM backup with optional DS1213B
- Calendar/time access & RAM backup with optional DS1216B
- 9-15V AC/DC Single-sided PCB 9.75" x 5.15"

Two add-on boards available. Relay Board to connect to real world of lights & motors and 8 x 8 LED module Board to write moving displays.

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Basic low cost counter. Two or more counter modules may be plugged together with 6-pin sockets & harness provided. Uses a single-unit 3-digit LED display. Built around the 14553 & 14551 chips. Box & battery provided. The separate COUNTER MODULE shows how to use the Kit as a counter. Has COUNT & RESET switches with debounce circuit built in to eliminate problems from noisy switches. 9V battery operation.

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Batteries soon become an expensive way to power your electronic kit and electronic games. This is a basic power supply using two 7805 regulators. Input up to 20V AC from a transformer or power pack. Two regulated outputs—fixed 5V, the other variable. Box provided. Good introduction to electronics.

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Introduction to LM3909. Continuity Tester & Long Life Flasher

Most ICs operate in the 4V to 40V range. The LM3909 from National Semiconductor changed this. Two PCBs supplied. A 1.5V D cell will flash an LED for over two years. Use as an imitation car alarm. A second PCB connects the chip as a 1.5V continuity tester. Seven pages of documentation provided from National Semiconductor.

CAT NO KIT 11EN — PRICE $9.95

Sound Activated Switch for Tape Recorder

Can be adjusted to turn on your tape recorder through its REMOTE plug. Has feedback and delay circuit for robust operation. Very sensitive. Proven circuit. Needs 6V plug pack for most stable operation.

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Record your phone conversations. Turns tape recorder on when the handset is lifted. Easy to connect to your phone line. Plugs into REMOTE & MIC jacks of your tape recorder. Best for 6V tape recorders. Educational Kit, not for illegal use.

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Miniature transmitter which attaches in series to one of the two lines to your telephone. Transmits over 200 meters to an ordinary FM receiver. Transmits further if the FM receiver is near the phone line. Tune with ceramic trim cap. Uses the phone line as an aerial and power source. Not for illegal use.

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Logic Probe

This is the most important piece of equipment for testing and measuring digital equipment. It is usually used in fault finding and testing, but can also assist in design work and to find out how digital equipment works. Switch for either TTL or CMOS. Our own modern design using a PUT. Includes detection circuit for very fast pulses. Gives visual (3 LED's) and audio (piezo buzzer) response.

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General Purpose 4-1/2 Digit Frequency Counter with LCD

General Purpose 4-1/2 Digit Counter uses Harris 7224 IC. Full instructions INCLUDING the 7224 data sheet is included. All pins from the 7224 are brought out for easy access. Directly drives an LCD (provided). This project is a building block that you can use as part of a larger project. The LCD section can be cut away and connected by a flat ribbon cable. The Kit has its own 5V regulated supply on board for the 7224, allowing a relatively wide range of voltage inputs from +6V to 10V. The Harris 7224 counts up to 15MHz, guaranteed, 25MHz typical.

CAT NO KIT 36EN — PRICE $42.00

Intro to Microcontrollers

Learn to program microcontrollers without going to technical college. This Kit introduces the Motorola 68HC705K1, an 8 bit, 16-pin microcontroller released in 1992. The Kit is a down counter from 60 or 90 seconds with beeps every 10 seconds. All the software code is supplied and fully explained. See how easy it is to change the time and beep settings by simple changes in the software program. You can judge for yourself how using micro-controllers is a huge advance over using logic ICs. On/off switch and pulldown resistors on input lines are all built into the K1 and are under software control. 9V battery powered.

All the information about how to continue learning to program these "computers-on-a-chip" is supplied. The tools to program the K1 are available at very low cost (under $200) from Motorola. The K1 is the simplest 8-bit microcontroller available.

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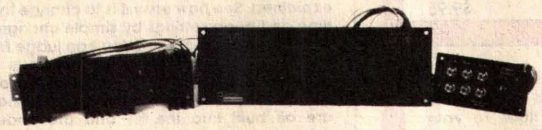

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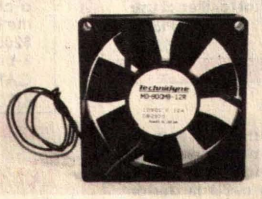

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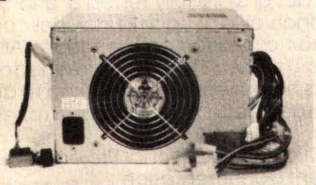

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7416	.40
7417	.40
7420	.40
7422	.54
7423	.54
7425	.50
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7427	.40
7428	.56
7430	.35
7432	.50
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7437	.35
7438	.40
7439	.89
7440	.35
7442	.55
7443	1.24
7444	1.24
7445	.99
7446	1.35
7447	1.35
7448	2.89
7450	.55
7451	.35
7453	.35
7454	.35
7460	.50
7470	1.09
7472	1.34
7473	.75
7474	.49
7475	.55
7476	.65
7480	.59
7482	2.29
7483	.89
7485	.55
7486	.55
7489	2.95
7490	.89
7491	1.09
7492	.99
7493	.69
7495	.55
7496	.69
7497	1.50
74100	4.95
74107	.35
74109	.39
74110	.60
74116	1.69
74120	1.29
74121	.54
74122	.99
74123	.65
74125	.55
74126	.55
74128	.75
74132	.55
74136	.55
74141	1.55
74142	2.59
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74144	6.95
74145	.99
74147	2.29
74148	1.25
74150	1.39
74151	.49
74153	.49
74154	1.59
74155	.59
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74159	1.89
74160	.89
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74162	.89
74163	.79
74164	.79
74165	.89
74166	.89
74167	2.65
74170	1.49
74172	5.95
74173	.89
74174	.59
74175	.59
74176	.99
74177	.69
74178	3.49
74179	2.30
74180	.89
74181	2.29
74182	1.19
74184	3.49
74185	3.49
74190	1.29
74191	1.09
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74193	1.09
74194	1.29
74195	.89
74196	.99
74197	.85
74198	1.79
74199	1.19
74221	.59
74246	4.95
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74249	4.95
74251	1.29
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74265	1.09
74273	2.95
74276	1.39
74278	2.19
74279	.59
74283	.95
74284	2.95
74285	2.69
74290	.99
74293	1.99
74298	.79
74351	2.59
74365	.69
74366	.69
74367	.49
74368	.55
74376	1.69
74390	1.39
74393	1.09
74425	1.69
74426	.99
74490	4.95

74LSxx

74LS00	.30
74LS01	.45
74LS02	.30
74LS03	.30
74LS04	.30
74LS05	.30
74LS06	.55
74LS07	.55
74LS08	.40
74LS09	.30
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74LS11	.35
74LS12	.35
74LS13	.40
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74LS19	.47
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74LS30	.35
74LS31	.35
74LS32	.40
74LS33	.40
74LS37	.35
74LS38	.35
74LS40	.35
74LS42	.45
74LS47	.89
74LS48	.89
74LS49	2.69
74LS51	.30
74LS54	.34
74LS55	.34
74LS63	.89
74LS73	.45
74LS74	.34
74LS75	.38
74LS76	.55
74LS78	.59
74LS83	.59
74LS85	.59
74LS86	.35
74LS90	.55
74LS91	.69
74LS92	.65
74LS93	.49
74LS95	.75
74LS96	.75
74LS107	.45
74LS109	.48
74LS112	.45
74LS113	.69
74LS114	.45
74LS122	.57
74LS123	.59
74LS124	2.69
74LS125	.45
74LS126	.45
74LS132	.59
74LS136	.49
74LS137	.59
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74LS139	.49
74LS145	.69
74LS147	1.59
74LS148	.89
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74LS158	.38
74LS160	.38
74LS161	.47
74LS162	.89
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74LS166	.65
74LS168	.99
74LS169	.99
74LS170	.69
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74LS174	.49
74LS175	.45
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74LS241	.65
74LS242	.69
74LS243	.69
74LS244	.69
74LS245	.75
74LS247	.79
74LS248	.99
74LS249	1.29
74LS251	.59
74LS253	.59
74LS256	1.00
74LS257	.45
74LS258	.55
74LS259	.69
74LS260	.59
74LS261	4.95
74LS266	.45
74LS273	.79
74LS275	2.19
74LS279	.45
74LS280	.69
74LS283	.65
74LS290	.65
74LS293	.65
74LS295	1.09
74LS298	.79
74LS299	1.59
74LS322	1.59
74LS323	1.59
74LS324	2.09
74LS327	1.09
74LS348	1.09
74LS352	1.09
74LS353	.99
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74LS683	2.19
74LS684	1.69
74LS685	8.00
74LS688	2.19
74LS689	3.50
74LS783	25.00

74Sxx

74S00	.35
74S02	.35
74S03	.35
74S04	.35
74S05	.35
74S08	.35
74S10	.35
74S11	.39
74S20	.35
74S22	.35
74S30	.35
74S32	.40
74S37	.25
74S38	.35
74S40	.35
74S51	.40
74S64	.35
74S65	.50
74S74	.35
74S85	.59
74S86	.25
74S112	.55
74S113	.35
74S114	.59
74S124	1.29
74S132	.35
74S133	.30
74S134	.45
74S135	.45
74S138	.40
74S139	.40
74S140	.55
74S151	.35
74S153	.35
74S157	.55
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74S189	1.89
74S194	.55
74S195	.55
74S197	.69
74S225	2.00
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74S241	.79
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74S253	.89
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74Fxx

74F00	.35
74F02	.35
74F04	.35
74F08	.35
74F10	.35
74F11	.35
74F14	.35
74F20	.35
74F21	.47
74F30	.47
74F32	.35
74F37	.47
74F38	.49
74F51	.59
74F64	.59
74F74	.35
74F85	2.09
74F86	.49
74F109	.65
74F112	.89
74F125	.89
74F126	.89
74F139	.69
74F148	1.09
74F151	.55
74F153	.69
74F157	.79
74F158	.79
74F160	1.49
74F161	.89
74F162	1.59
74F163	.89
74F164	.69
74F166	.89
74F169	3.39
74F174	.79
74F175	.79
74F182	2.09
74F189	14.99
74F191	3.09
74F193	2.95
74F194	1.29
74F195	1.79
74F240	.79
74F241	.89
74F244	.79
74F245	.79
74F251	.79
74F253	.79
74F257	.79
74F258	.69
74F280	.99
74F283	1.19
74F299	4.50
74F350	2.29
74F367	.99
74F373	.69
74F374	.69
74F377	1.19
74F381	4.49
74F399	1.59
74F521	1.29
74F533	2.29
74F573	2.99
74F574	2.99
74F623	1.59
74F646	4.95

74Cxx

74C00	.45
74C02	.45
74C04	.40
74C08	.40
74C10	.45
74C14	.69
74C20	.35
74C30	.45
74C32	.59
74C42	2.09
74C48	2.95
74C73	1.29
74C74	.79
74C76	1.09
74C85	1.59
74C86	.69
74C90	1.59
74C93	1.59
74C95	1.09
74C107	4.95
74C151	2.95
74C154	3.95
74C157	1.99
74C160	1.59
74C161	.89
74C162	1.59
74C163	1.59
74C165	1.59
74C174	.89
74C175	.89
74C192	1.39
74C193	1.59
74C195	1.59
74C221	2.09
74C240	2.09
74C244	2.09
74C373	2.09
74C901	1.09
74C902	1.09
74C903	1.09
74C904	1.59
74C905	6.95
74C906	1.25
74C907	.99
74C909	3.95
74C911	12.95
74C912	2.69
74C915	2.49
74C917	9.95
74C921	6.95
74C922	5.95
74C923	9.95
74C925	9.95
74C926	9.95

74HCxx

74HC00	.30
74HC02	.30
74HC04	.30
74HC08	.30
74HC10	.30
74HC11	.34
74HC14	.35
74HC20	.30
74HC21	.55
74HC27	.34
74HC30	.34
74HC32	.30
74HC42	.55
74HC51	.30
74HC73	.55
74HC74	.40
74HC75	.35
74HC76	.79
74HC85	.55
74HC86	.40
74HC93	1.39
74HC107	.45
74HC109	.45
74HC112	.45
74HC123	.50
74HC125	.55
74HC126	.59
74HC132	.59
74HC133	.49
74HC137	.79
74HC138	.49
74HC139	.49
74HC147	.89
74HC148	.89
74HC151	.59
74HC153	.45
74HC154	1.29
74HC157	.59
74HC158	.49
74HC161	.59
74HC163	.59
74HC164	.59
74HC165	.69
74HC166	.59
74HC174	.59
74HC175	.59
74HC191	.89
74HC192	.89
74HC193	.79
74HC194	.79
74HC221	.69
74HC237	.79
74HC238	.89
74HC240	.69
74HC241	.69
74HC242	.89
74HC243	.89
74HC244	.79
74HC245	.79
74HC251	.59
74HC253	.59
74HC257	.59
74HC258	.69
74HC259	.89
74HC273	.89
74HC280	.92
74HC299	1.09
74HC367	.69
74HC368	.69
74HC373	.69
74HC374	.69
74HC390	.59
74HC393	.69
74HC517	.69
74HC540	1.09
74HC541	.89
74HC573	.89
74HC574	.89
74HC595	1.29
74HC640	1.85
74HC652	1.79
74HC688	1.19
74HC4017	.99
74HC4020	.89
74HC4024	.99
74HC4040	.89
74HC4049	.59
74HC4050	.59
74HC4051	1.29
74HC4060	.79
74HC4075	.49
74HC4351	1.39
74HC4511	2.19
74HC4515	2.69
74HC4538	.79
74HC22106	8.95

74HCTxx

74HCT00	.30
74HCT02	.30
74HCT04	.35
74HCT08	.35
74HCT10	.35
74HCT11	.40
74HCT14	.47
74HCT20	.35
74HCT27	.35
74HCT30	.49
74HCT32	.35
74HCT38	.39
74HCT74	.45
74HCT75	.40
74HCT85	.89
74HCT86	.49
74HCT109	.49
74HCT123	.75
74HCT125	.59
74HCT132	.59
74HCT138	.59
74HCT139	.59
74HCT151	.59
74HCT154	1.99
74HCT157	.59
74HCT158	.59
74HCT161	.79
74HCT163	.59
74HCT164	.79
74HCT165	.79
74HCT166	.79
74HCT173	.69
74HCT174	.59
74HCT175	.59
74HCT191	.69
74HCT193	.79
74HCT194	.79
74HCT195	.79
74HCT237	.89
74HCT238	.79
74HCT240	.79
74HCT241	.79
74HCT242	.89
74HCT243	.79
74HCT244	.79
74HCT245	.79
74HCT251	.69
74HCT257	.69
74HCT259	.79
74HCT273	.79
74HCT280	.69
74HCT299	1.09
74HCT367	.69

Thousands more.. Full list includes - ALS, 4000, etc.

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LM35CH	11.00
LM10	2.39
TL061	1.19
TL062	1.19
TL064	1.09
TL066	.99
TL071	.75
TL072	.75
TL074	1.09
TL081	.65
TL082	.65
TL083	1.09
TL084	1.09
LM150K	4.95
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LM208	.50
XR215	1.50
MAX231	2.99
MAX232	2.79
MAX233	6.50
MAX238	6.50
LM301	.49
LM301H	.89
LM307	.49
LM308	.75
LM309H	4.25
LM309K	2.09
LM310	1.89
LM311	.49
LM311H	.99
LM312H	5.50
LM316	4.00
LM317K	2.09
LM317T	.79
LM317	.69
LM320K	4.49
LM320T	2.99
LF351	.65
LF353	.60
LF355	.99
LF356	.89
LF357	1.00
LM358	.59
LM359	2.09
LM376	1.39
LM380	1.09
LM380N-8	1.19
LM381	3.95
LM382	2.49
LM383	3.69
LM384	1.89
LM385Z 1.2	1.95
LM386N-1	.69
LM386N-3	.95
LM386N-4	1.29
LM387	1.89
LM389	1.49
LM390	1.79
LM391	3.95
LM392	1.29
LM393	.45
LM395K	9.95
LF398	1.99
LM399H	3.99
LF411	.85
LF412	1.35
ZN414Z	2.49
LF442	1.39
LF444	1.89
TL489	1.59
TL494	1.89
TL496	1.59
TL497	2.09
NE531T	1.99
LM555	.45
LM555C	.69
XRL555	.90
SE555	.75
LM556	.59
LM558	.79
NE564	1.79
LM565	1.59
LM566	1.29
LM567	.79
NE570	2.99
NE571	2.09
NE590	2.69
NE592	.45
NE602	1.95
MAX663	3.69
MAX666	3.89
MAX680	3.49
MAX690	5.99
MAX691	5.99
MAX692	6.50
MAX694	6.50
MAX695	6.50
LM709	.80
LM710	.80
LM711	.89
LM723	.59
LM723H	1.29
MAX732	5.50
LM733	.89
LM741	.40
LM741HC	1.09
LM747	.69
LM748	.69
LM1014	2.69
SA1027	6.99
MAX1232	3.29
LM1303	1.69
LM1310	1.39
MC1330	1.69
MC1349	2.09
MC1350	.99
MC1358	.99
MC1372	2.69
MC1374	2.00
MC1404	1.99
MC1405	1.99
MC1408-6	1.99
MC1408-8	1.89
MC1411	1.99
MH1414	1.69
MC1456	1.50
MC1458	.47
LM1488	.50
LM1489	.50
MC1496	.99
MPM1520	1.39
MC1558	2.59
MC1558G	2.59
MC1648	.90
MC1723CL	1.00
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LM1800	2.69
LM1812	7.95
LM1830	4.95
LM1871	5.95
LM1872	5.95
LM1877	3.95
LM1881	4.95
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LM1896	1.99
ULN2001	.79
ULN2003	.79
ULN2004	.79
XR2206	3.99
XR2207	2.49
XR2208	2.69
XR2211	2.69
XR2240	1.69
XR2242	1.50
XR2567	2.50
ULN2803	1.09
LM2877	2.19
LM2878	5.95
LM2900	2.19
LM2901	.69
LM2903	.49
LM2907	1.69
MPQ2907	2.69
LM2917	2.19
CA3018	1.50
CA3037	1.50
CA3039	1.49
CA3046	.89
CA3059	1.69
CA3060	2.95
CA3065	1.69
CA3080	.90
CA3081	.79
CA3082	1.09
CA3083	.79
CA3086	.79
CA3089	1.59
CA3096	1.69
TCM3105	6.95
CA3126	1.45
CA3130	.89
CA3140	.79
CA3146	1.09
CA3160	1.09
CA3161	1.99
CA3162	6.00
CA3183	.99
MC3302	.75
MC3340	1.69
MC3346	1.99
MC3360	1.50
MC3373	1.09
CA3401	1.50
MC3401	.90
MC3403	.70
MC3470	1.29
MC3479	4.29
MC3480	9.95
MC3486	1.09
MC3487	1.09
SG3524	1.79
LM3900	.69
LM3905	.99
LM3909	1.49
LM3911	1.99
LM3914	2.69
LM3915	2.69
LM3916	2.69
MC4001	4.00
MC4016	2.75
MC4024	2.79
MC4044	4.99
MC4136	1.19
RC4136	1.09
RC4151	1.09
RC4558	.79
MC4741	.50
NE5205	2.39
NE5532	1.19
NE5534	.99
NE5539	2.49
ICL7106	5.49
ICL7107	5.49
ICL7109	9.95
ICM7207	7.95
ICM7208	20.00
ICM7216	25.00
ICM7231	9.49
ICM7551	.89
ICM7556	1.49
ICL7660	1.99
ICL7663	3.25
ICL7665	3.49
MAX640	1.29
ICL8038	3.79
ICL8211	2.49
LF13741	.99
LM13080	1.59
LM13600	.99
LM13700	1.29
75107	.79
75108	.89
75110	.89
75138	2.69
75150	1.29
75150 (SK)	1.29
75154	1.29
75160	3.75
75174	2.39
75175	2.39
75176	2.09
75188	.50
75189	.50
75365	.89
75450	.59
75451	.49
75452	.59
75453	.59
75454	.59
75477	.99
75491	.89
75492	.99
75493	.99
75494	.99
MC145026	1.69
MC145027	2.19
MC145028	2.19
MC145151	7.95
MC145406	2.29
MC146818	4.19

EPROM

1702	4.95
2516	4.95
2532	8.99
2708	4.95
2716	4.25
27C16	6.95
2732A	4.25
2732A-2	4.50
27C32	4.50
2764	3.95
2764-2	4.50
2764-15	4.95
27C64	3.50
27C64-2	3.75
27C64-15	3.95
27128	4.75
27128A-2	5.00
27128A-15	7.00
27C128	5.00
27C128-150	5.50
27256	4.95
27256-2	5.50
27256-15	5.75
27256-170	5.75
27C256	4.95
27C256-2	5.50
27C256-15	5.95
27C256-100	6.95
27512	6.00
27512-20	6.50
27C512	6.00
27C512-15	6.95
27C101-200	7.95
27C101-100	9.95
27C201-150	10.95
27C201-100	13.95
27C401-150	19.95
27C401-100	29.95

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2816-450	3.75
2816-250	4.25
2816-150	4.50
28C16-150	3.95
28C64-250	7.95
28C64-250	7.39
28C64-150	7.95
28C256-250	27.95
28C256-150	29.95

Dallas

DS1202	4.69
DS1228	6.49
DS1259	8.00
DS1260	15.00
DS1287	15.00
DS2130	17.00

SRAM

2016	2.69
2101	1.99
5101	2.79
2102	.99
2111	1.99
2114	1.29
2125	1.95
2147	2.09
2148	2.09
6116LP-3	2.79
6116LP-2	3.25
6116LP-1	3.29
6264LP-15	4.25
6264LP-12	4.50
6264LP-10	4.75
6264-15	3.99
6264-12	4.19
6264-10	4.39
2064-100	6.25
62256LP-12	4.95
62256LP-10	5.50
62256LP-70	6.25
628128LP10	16.95
628128LP85	17.95

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LM150K	4.95
LM317K	2.09
LM317T	.79
LM317	.69
TL317(TO92)	.70
LM337K	3.59
LM337T	.99
LM338K	4.95
LM338T	2.95
LM339	.55
LM340K	3.95
LM340T	.69
LM345K	2.95
LM723	.59

Positive

78L05	.45
78L62	.45
78L12	.45
78L15	.45
7805T	.59
7806T	.59
7808T	.59
7810T	.59
7812T	.59
7815T	.59
7805K	1.79
7812K	1.79
7815K	1.79
78M05	.59
78M08	.59
78M12	.59
78M15	.59
78M24	.59
7824T	.59
78S40	1.95

Negative

79L05	.45
79L12	.45
79L15	.45
7905T	.59
7906T	.59
7908T	.59
7910T	.59
7912T	.59
7915T	.59
7905K	1.79
7912K	1.79
7915K	1.79
79M05	.59
79M08	.59
79M12	.59
79M15	.59
79M24	.59
7924K	.59
7924T	1.79

PAL

10L8	2.35
12L6	2.35
16C1	6.95
16R4	2.35
16R4-10	2.95
16R4-12	2.75
16R4-15	2.55
16R4-25	2.35
16R6	2.35
16R6-10	2.95
16R6-20	2.55
16R6-25	2.35
16L8	2.35
16L8-15	3.49
16L8-25	2.35
16R8	2.35
16R8-15	3.25
16R8-20	2.50
20R4	2.65
20R6	2.35
20R6-15	2.75
20L8	2.35
20L8-15	2.95
20L8-20	2.95
20R8	2.35
20X10	4.95
22V10	6.95
22V10-15	14.95
22V10-25	6.95

A To D

ADC0800	25.00
ADC0802	7.00
ADC0804	3.25
ADC0808	6.49
ADC0809	3.99
ADC0816	20.00
ADC0817	17.00
ADC0820	11.00
ADC0831	3.99
ADC1205	46.00

D To A

DAC0800	2.09
DAC0806	1.99
DAC0808	1.89
DAC0830	7.49
DAC1020	9.49
DAC1021	8.49
DAC1022	6.49

OPTO

MCT-2	.79
MCT-6	1.50
H11A4	.89
H11C3	2.95
H13A1	.75
H21A3	4.00
4N25	.75
4N26	.60
4N27	.69
4N28	.69
4N32	.79
4N33	.79
4N35	.79
4N37	.79
4N45	.89
LO-74	2.95
TIL111	1.00
TIL113	1.00
6N136	2.25
6N137	2.50
TIL139	1.19
6N139	1.79
MCA255	1.09
HA1137W	.69
MOC3010	1.19
MOC3011	1.29
MOC3020	1.39
MOC3021	1.49
HP3700	2.25

Transistors

NSDUO1	.25
MPSU02	.25
MPSA-05	.20
MPSA-06	.20
VN10	1.95
MPSA-13	.25
MPSA-20	.30
PP20	.50
TIP30	.50
TIP31	.50
TIP32	.50
TIP33	.70
TIP34	.70
TIP41	.55
TIP42	.55

SILVER SUCCESS STORY:

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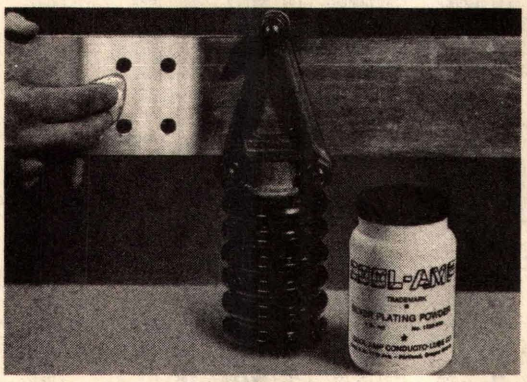

Time-proven since 1944. Minimizes overheating and power loss, assures cool conductivity for copper, brass and bronze contacts. Applies easily *on the job.* Adheres permanently. Equal to electroplating in performance. Reduce maintenance time, prevent power losses from oxidation.

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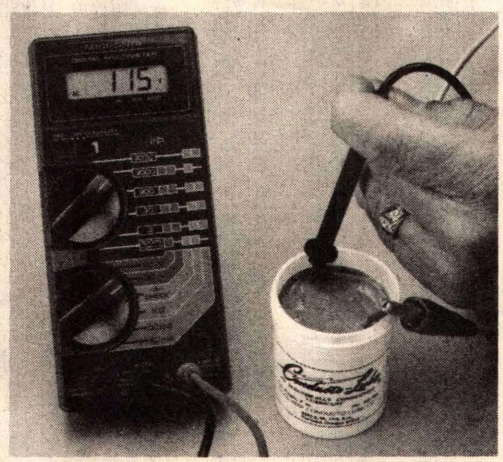

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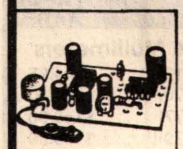
RAINBOW KITS



SUPER SNOOPER BIG EAR

Listen through walls, hear conversations across the room. Add a parabolic reflector & hear blocks away. The BIG EAR can be hidden about anywhere. Makes an ultra- sensitive intercom, Can be used as a 1.5W AMP. We supply a mini- electret mike in the kit. 1"x1.75" 6 to 12vDC

AA-1 **$10.95**

PHONE TRANSMITTER

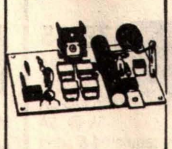
Small but mighty, it fits anywhere. Phone line powered, never needs batteries Transmits both sides of a phone conversation loud and clear, wireless, to any FM radio at great distances. Variable tunes from 70MHz TO 130MHz FM. You can also use it as a speaker phone. Size .5"x1"

TEL-B1 **$12.95**

PHONE RECORDING SWITCH

This phone line powered switch is small enough to be installed any where. Every time the phone is picked up the recorder will record both sides of the conversation automatically. Use it in your office to record all phone calls so you don't loose important information. 1"x.6"

TEL-SW1 **$12.95**



STROBE LIGHT

If you need an attention getter, warning light, or flashing light for model airplanes, then this kit is for you. Use it as an emergency light for your auto, radio tower, even use it on your bicycle. Has a varible flash rate. Size 3.5"x1.8" operates on 6 or 12v DC only.

ST-1 **$9.95**

DIGITAL THERMOMETER

The DT-3 kit will turn your digital volt meter into an accurate digital thermometer with .1 degree resolution. Measures temperature from -40F to 250F degrees. It has a remote sensor .25" SQ. and can be mounted many feet away from the meter. Size 1.5x1.2" 9vDC

DT-3 **$8.95**

CAPACITANCE METER

This kit will turn your digital volt meter into a capacitance meter. Turn that junk box of unmarked capacitors into a fortune of usable parts. Measures capacitors from <2.2pF to 2.2uF. 1.75"x2" 9vDC

CA-1 **$12.95**

TEMPERATURE GENIE

Ever lost frozen food because your freezer stopped? The TC-2 kit would have saved you money. An alarm activates when the temp. reaches that critical degree. Turn ceiling fans on automatically when it gets to hot. This kit gives you 100MA of output. 1.5"x1.2" 6 to 15vDC

TC-2 **$7.95**

LIGHT GENIE

Turn anything on or off with light, night light, security lights, turns on at night off at daylight automatically. As the light touches or leaves the sensor it delivers 100 MA of output to run a relay. Size 1.5"x1.2" 6 to 15vDC

LG-2 **$7.95**

CHASER LIGHTS

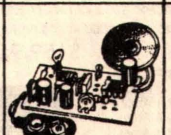
Use this kit like a theater marquee. Every forth led chases around the display to give you a dazzling effect. You can use 40 led's around badges, pictures, hats, belts, signs, only your imagination limits the possibilities. Kit supplied with 16 leds. SIZE 1.3"x1.6" 4 to 9vDC

CL-1 **$15.95**

BUSY PHONE LIGHT

Add this little kit to any or all of your phones. When one phone is in use an LED will light on the other extension. This lets everyone know when your computer modem is in use. Requires 9vDC 1"x1/2"

TEL-LITE **$9.95**



RADAR SIGNAL DETECTOR

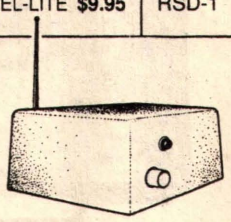
The RSD-1 kit won't replace a $200.00 unit but this simple yet effective detector circuit can be built in less than an hour and can be tuned to respond to signals from 50MHz to 500GHz. We supply a lighter plug. 1"x1.75" 9 to 15vDC

RSD-1 **$12.95**

LIQUID LEVEL DETECTOR

Use this kit to turn on a relay for a sump pump. Add this to your security system to turn on an alarm when water reaches a certain level. This kit will give you 100Ma of output. Size 1.5"x1.2 9vDC

LL-1 **$9.95**

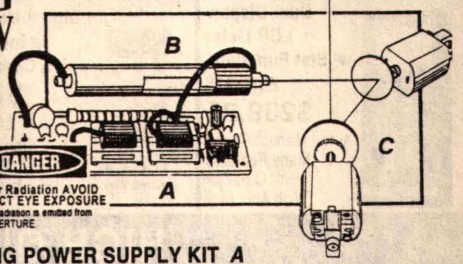


With the **FMST-100,** you have a wireless link to Any FM stereo radio. Transmit your CD player while mowing the lawn, from your camper to your car, through out an auditorium, around the neighborhood, even transmit music on one channel and sing on the other. Compatible with any of your audio equipment. The clarity is excellent, uses a crystal for approximately 40dB of stereo separation. The length of antenna determines how long it transmits. The output is tuneable from 76 to 108MHz FM. Comes with a left & right input level adjust. operates on 9vDC. 1.5"x1.6"

FMST-100 **$29.95**
Enclosure **$ 8.95**

EXCITING RAINBOW LASER KITS

ALL 3 FOR **$99.95**



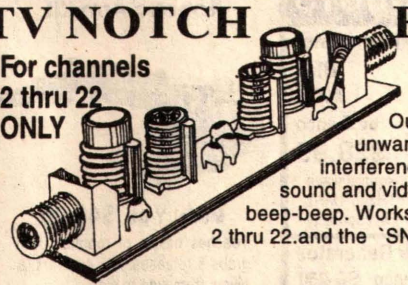
LASER SWITCHING POWER SUPPLY KIT *A*
Input 12vDC 1A, Output 2 to 3KV at 3-4.5ma. triger voltage of aprox. 8-10KV. Complete with P.C. Board 6.25"x 2.25" schematic & all parts. LPS-1 **$59.95**

1MW He-Ne LASER TUBE *B*
Approx. 1"x 5.75" perfect for experimenters laser projects. Works great with LPS-1 power supply. L1MN-1 **$39.95**

MIRROR MOTOR KIT *C*
Project Lissajous paterns on the walls. Change the patterns by changing the speed of the motors. Comes complete with 2 motors, 2 front surface mirrors, mounting brackets, & speed control. MM-2 **$19.95**

TV NOTCH FILTERS

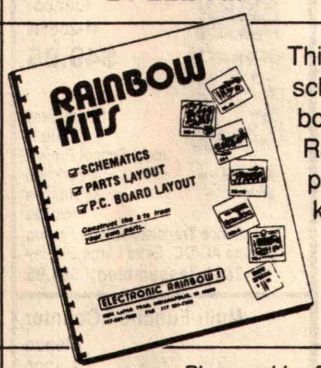
For channels 2 thru 22 ONLY



Our TV filters eliminate unwanted TV channels or interference that alters both sound and video with a beep-beep-beep. Works on cable channels 2 thru 22.and the `SNOOPER & BULLET.

NOTE: All TV Filter Kits are sold for educational purposes only. You must obtain permission from your local cable company before using these filters on your cable system.

DF222 Kit **$14.95**



This Manual contains all schematics, parts & P.C. board layouts for all of the Rainbow Kits. Use your own parts to construct any of our kits.

KIT BOOK **$14.95**
$5.00 off if you buy any kit

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All Models Available - Call

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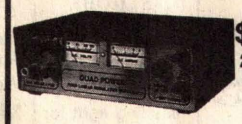
High Current Power Supply

Spectrum by Elenco
2.5 - 15VDC or 13.8VDC
Fully regulated, Short circuit protected
Voltage/Current Analog Meters
SPL-010 0-10A **$139** SPL-020 0-20A **$199**

12A DC Power Supply
B+K 1686

$169.95
3-14V @ 12A
Fully regulated & protected
Separate Volt & Current Meters
Current Limiting, Low Ripple

Quad Power Supply XP-580



$79.95
2-20V @ 2A
12V @ 1A
5V @ 3A
-5V @ .5A
Fully regulated & short circuit protected
Made in USA by Elenco

Triple Power Supply XP-620
Assembled $75
Kit $49.95

2 to 15V @ 1A,
-2 to -15V @ 1A
(or 4 to 30V @ 1A)
and 5V @ 3A
Made in USA by Elenco
All the desired features for doing experiments.
Features short circuit protection, all supplies.

GENERATORS & VIDEO PRODUCTS

Function Generator

Blox
#9600
by Elenco
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Provides sine, triangle, square wave from 1Hz to 1MHz
Kit $26.95 AM or FM capability

Color Convergence Generator

Elenco SG-250
$89.95
Kit $69.95
Finest in the industry
10 rock steady patterns
RF & Video output

Wide Band Signal Generators

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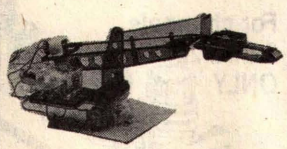
RF Freq 100K-450MHz AM Modulation of 1KHz Variable RF output
SG-9500 w/ Digital Display & 150MHz built-in counter $239

Sweep/Function Generator with Freq. Counter

$239
Elenco GF-8026
Int/Ext Operation,
Sine, Square, Triangle, Pulse, Ramp, .2 to 2MHz, Freq Counter .1-10MHz

EDUCATIONAL KITS - FUN & EASY TO BUILD

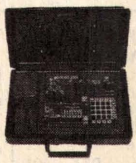
Robotic Arm Kit



Model Y-01 $48.95
Teaches basics of robotics. Arm grabs & releases, lifts & lowers, & pivots from side to side

AM/FM Transistor Radio Kit
with 52 page Training Course
Elenco AM/FM 108
$27.95
14 Transistors ◆ 5 Diodes
Easy to build because schematic is printed right on the PCB
Makes a great school project
Model AM 550 AM Only $18.95

Learn to Build and Program Computers with this kit



Includes: All Parts, Assembly and Lesson Manual
Elenco MM-8000
$129.00
Starting from scratch you build a complete system. Our Micro-Master trainer teaches you to write into RAMs, ROMs and run a 8085 microprocessor, which uses similar machine language as IBM PC..

Digital Multimeter Kit
with Training Course

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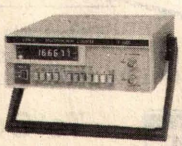
Fun & Easy to Build
Ideal School Project
Full Function
34 Ranges
Includes Capacitance, Transistor/Diode Testing
20Amp AC/DC, Extra Large Display
M-2661 (assembled) $54.95

Multi-Function Counter



Elenco F-1200
1.2GHz
$229
Measures Frequency, Period, Totalizer
8 LED digits, Crysral Oven Oscillator
.5ppm Accuracy

XK-500 Digital / Analog Trainer

A complete mini-lab for building, testing, prototyping analog and digital circuits
Elenco's Digital/Analog Trainer is specially designed for school projects, with 5 built-in power supplies. Includes a function generator with continously variable, sine, triangular, square wave forms. All power supplies are regulated and protected against shorts.

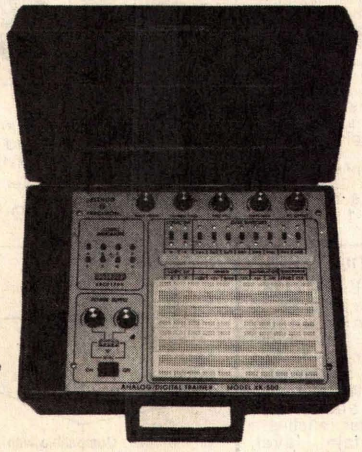
$159.95 Assembled $129.95 Kit

Power Supplies
- Variable Power Supply
- +1.25 to 20VDC @ .5 Amp (+1.25 to 15VDC @ 1 Amp)
- -1.25 to -20VDC @ .5 Amp (-1.25 to -15VDC @ 1 Amp)
- +12VDC @ 1 Amp
- -12VDC @ 1 Amp
- +5VDC @ 1 Amp
- 30VAC Center tapped @ 15VAC at 1 Amp

Analog - Section
- Function Generator Sine, Triangular, Square wave forms
- Frequency adjustable in five ranges from 1 to 100KHz
- Fine frequency adjust
- Amplitude adjust
- DC offset
- Modulation FM-AM

Digital - Section
- Eight data swiches
- Two no bounce logic switches
- 8 LED readouts TTL buffered
- Clock frequency 1 to 100KHz
- Clock amplitude 5VPP square wave

Breadboards
- 2 breadboards, each contain: 840 tie points (total 1,680)



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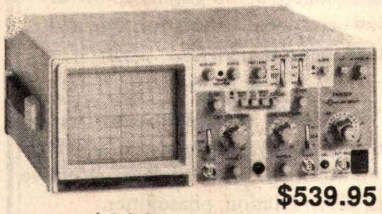


$539.95

20MHz $389
2 Channel

Model 2125
Delayed Sweep

40MHz DUAL-TRACE

Model 1541B

$695.95

- 1mV/div sensitivity
- Video sync separators
- Z axis input
- Single sweep
- V mode-displays two signals unrelated in frequency.

60MHz DUAL-TRACE

Model 2160

$949.95

- 1mV/div sensitivity
- Sweep to 5 ns/div
- Dual time base
- Signal delay line
- V mode-displays two signals unrelated in frequency
- Component tester

100MHz THREE-TRACE

Model 2190

$1,395.95

- 1mV/division sensitivity
- Sweeps to 2ns/division
- Dual time base
- Calibrated delay time multiplier
- Signal delay line
- 19kV accelerating voltage

20MHz ANALOG WITH DIGITAL STORAGE

Model 2522A

$875

- 20MHz analog bandwidth
- 20MS/s sampling rate
- 2k memory per channel
- 20MHz equivalent time sampling
- Pre-trigger capture

AFFORDABLE - ELENCO OSCILLOSCOPES

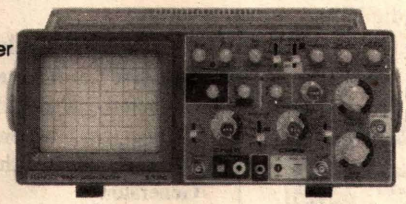
2 YEAR WARRANTY

S-1360 Delayed Sweep $775

60MHz Dual Trace

S-1365 Cursor Readout $849

- Automatic Beam Finder
- Built-in Component Tester
- 1mV Sensitivity
- Dual Time Base
- Illuminated Internal Gradicule
- TV Sync



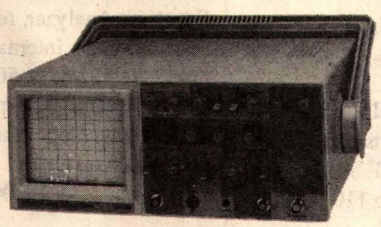
- Voltage, Time, + Frequency differences displayed on CRT thru the use of cursors.
- 1mV Sensitivity
- TV Sync

S-1345 Delayed Sweep $575

40MHz Dual Trace

S-1340 $495

- Automatic Beam Finder
- Built-in Component Tester
- 1mV Sensitivity
- Dual Time Base
- Illuminated Internal Gradicule
- TV Sync



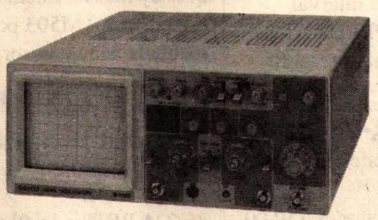
- High luminance 6" CRT
- 1mV Sensitivity
- 12KV Acceleration Voltage
- 9ns Rise Time
- X-Y Operation
- TV Sync

S-1330 Delayed Sweep $449

25MHz Dual Trace

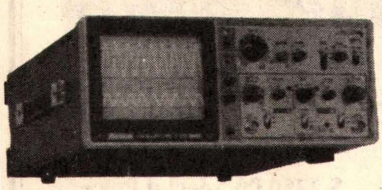
S-1325 $349

- Automatic Beam Finder
- Built-in Component Tester
- 1mV Sensitivity
- Dual Time Base
- Illuminated Internal Gradicule
- TV Sync



- High luminance 6" CRT
- 1mV Sensitivity
- 2KV Acceleration Voltage
- 18ns Rise Time
- X-Y Operation
- TV Sync

SPECIAL BUY HITACHI V-212



20MHz
2 Channel

$399

Hitachi Popular Series

V-525 - 50MHz, Cursors	$995
V-523 - 50MHz, Delayed Sweep	$949
V-522 - 50MHz, DC Offset	$895
V-422 - 40MHz, DC Offset	$795
V-222 - 20MHz, DC Offset	$649

Hitachi Compact Series Scopes

V-660 - 60MHz, Dual Trace	$1,149
V-665A - 60MHz,DT, w/cursor	$1,325
V-1060 - 100MHz, Dual Trace	$1,395
V-1065A - 100MHz, DT, w/cursor	$1,649
V-1085 - 100MHz, QT, w/cursor	$1,995
V-1100A - 100MHz, Quad Trace	$2,495
V-1150 - 150MHz, Quad Trace	$2,895

Elenco DS-203 20MHz, 10MS/s Digital Storage Oscilloscope

$775

- 2K Word Per Channel
- Plotter Output
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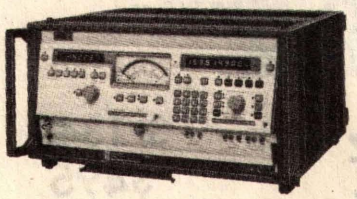
Wiltron 560A

Scaler Network Analyzer, 10 MHz to 40 GHz range depending on detector used. GPIB programmability, includes 2 detectors.

$1750.00

Wandel & Goltermann SPM-16

Selective Level Meter, 10 Hz to 160 MHz, high frequency accuracy, uncertainty less than 1 x 10 -7, digital and analog display.



Special $ 975.00
Originally cost over $ 50K

Hewlett-Packard 141T System

Spectrum Analyzer consists of 1 8552B IF Section and 1 8553B RF Section & 141T Mainframe. 1 kHz to 110 MHz.

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Racal Dana 1996

Universal Systems Counter, DC to 1.3 GHz, 1 nS single shot time interval resolution, 9-digit, full GPIB programmability, phase, slew & duty measurement. **$ 795.00**

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PG 506 Calibration Generator $1150.00

TG 501 Time Mark Generator $ 750.00

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TM 503 RACK with the above Plug-Ins PG 506, TG 501, & SG 503.

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Hewlett-Packard 8565A

Spectrum Analyzer, 10 MHz to 22 GHz with internal mixing, up to 40 GHz with external mixing. Wide resolution range, 1 kHz to 3 MHz.

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Hewlett-Packard 3336B

Synthesized/ Level Generator is an excellent precision source from 10 Hz to 20.9 MHz, frequency resolution of .001 Hz, level accuracy within .15 dB over full range, AM and phase modulation . Fully programmable over HP-IB, harmonics down more than 5 dB.

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Hewlett-Packard 3586B

Selective Level Meter, makes carrier measurements to 32.5 MHz. Voice channel measurements from 50 Hz to 100 kHz, works with 3336 Level Generator.

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Buy Both Together as a Set for $1300.00

Tektronix 492P Opt 01, 02, & 03

Spectrum Analyzer, fully programmable, digital storage, internal preselection, frequency stabilization, 50 kHz to 21 GHz standard, amplitude specified coverage to 220 GHz with optional Tektronix waveguide mixers.

$ 14,000.00

Tektronix TR 503

Tracking Generator works with all 490 series spectrum analyzers, swept frequency measurements to 1.8 GHz. New boxed with TM503 power module. All manuals and accessories included.

$ 2500.00

Hewlett-Packard Sweep Systems

8620C Sweep Oscillator Mainframe	$ 850.00
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86230B RF Plug-In 1.8 to 4.2 GHz	$ 1100.00
86235A RF Plug-In 1.7 to 4.3 GHz	$ 1200.00
86240B RF Plug-In 2.0 to 8.4 GHz	$ 1250.00
86242A RF Plug-In 5.9 to 9.0 GHz	$ 1050.00
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86290A RF Plug-In 2.0 to 18.0 GHz	$ 1975.00
86290B RF Plug-In 2.0 to 18.6 GHz	$ 3250.00

Tektronix 2230

100 MHz Digital Storage/ Nonstorage Oscilloscope, 100 nS glitch capture at any sweep speed, cursors for time and voltage measurements.

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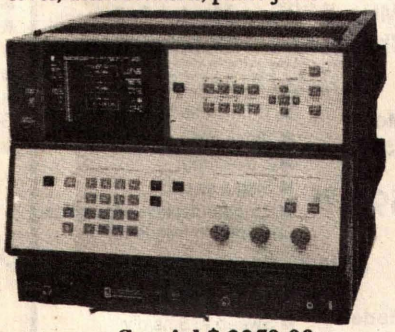
Wandel & Goltermann TSA-1

Transmission System Analyzer. 100 Hz to 180 MHz, spectrum analysis, selective level, demodulation, phase jitter.



Special $ 2250.00
Same as above but includes network analyzer
Special $ 2750.00

Hewlett-Packard 8350A/ 83592A

RF Plug-In and Sweep Oscillator Mainframe. 0.01 to 20 GHz, + 6.3 minimum leveled output.

$ 13,500.00

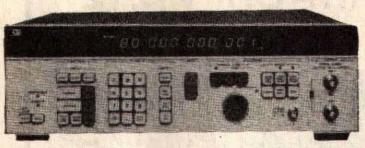
Wavetek SAM 1-450

Signal Level Meter, simple hum and carrier-to-noise measurement, built-in calibrator, frequency range 4 MHz to 450 MHz, extremely portable.

$ 895.00

Hewlett-Packard 3335A

Synthesizer/ Level Generator, 200 Hz to 81 MHz, .001 Hz resolution, high spectral purity, precision amplitude control, program storage, 11 digit display HP-IB.



$ 2750.00 Special Price

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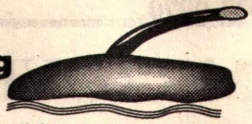
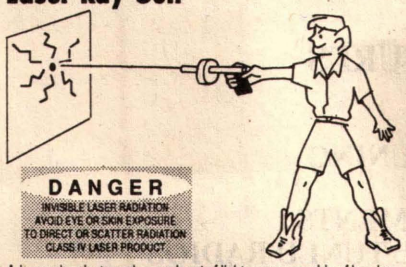
Mystery Levitating Device!



Remember War of the World? Objects float in air and move to the touch. Defies gravity, amazing gift, conversation piece, magic trick or great science project.

ANT1K Easy to Assemble Kit / Plans $19.50

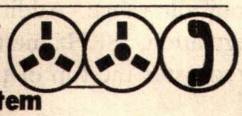
Laser Ray Gun



Advanced project produces a burst of light energy capable of burning holes in most materials. Hand-held device uses rechargeable batteries. 500 joules of flash energy excite either a neodynium glass, yag or other suitable 3" laser rod. This is a dangerous CLASS IV project (individual parts/assemblies available).

LAGUN1 Plans $20.00
LAGUN1K Kit / Plans ..... Price on Request

Extended Play Telephone Recording System



READY TO USE! Automatically controls and records on our X-4 extended play recorder, taping both sides of a telephone conversation. Intended for order entry verification. Check your local laws as some states may require an alerting beeper.

TAP20X Ready to Use System $129.50

Shocker Force Field/ Vehicle Electrifier

Neat little device allows you to make hand and shock balls, shock wands and electrify objects, charge capacitors. Great payback for those wise guys who have wronged you!

SHK1KM Easy to Assemble Electronic Kit $24.50

Blaster Pulser

Pocket-sized wand produces 100,000 watts of power for personal defense, field and lab use, etc. BLS3 Plans $10.00
BLS3K Kit / Plans $69.50

Homing / Tracking Transmitter

Beeper device, 3 mile range.

HOD1 Plans .....$10.00 HOD1K Kit / Plans $49.50

Listen Through Walls, Floors

Highly sensitive stethoscope mike.

STETH1 Plans.....$8.00 STETH1K Kit/Plans $44.50

NEW! INFINITY TRANSMITTER++

Room Monitor / Phone Line Grabber

ALL NEW! The Ultimate in Home or Office Security & Safety! Simple to Use! Call your home or office phone, push a secret tone on your telephone keypad to access either: A. On premises sounds and voices; or B. Existing telephone conversation with break in capability for emergency messages. CAUTION: Before assembly or use, check legalities with your state Attorney General's office as you may require "beepers" or other 3rd party alerts.

TELEGRAB1 Plans Only $10.00
TELEGRAB1K Kit / Plans $99.50

Ultrasonic Blaster

Laboratory source of acoustical shock waves. Blow holes in metal, produce "cold" steam, atomize liquids. Many cleaning uses for PC boards, jewelry, coins, small parts, etc.

ULB1 Plans.....$10.00 ULB1K Kit/Plans.....$69.50

100,000V Intimidator / Shock Wand Module

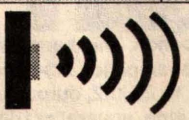
Build an electrical device that is affective up to 20 feet. May be enclosed for handheld, portable field or laboratory applications.

ITM2KM Easy-to-Assemble Electronics Kit $49.50
ITM2 Plans only, credit-able to kit $10.00

Ion Ray Gun

Projects charged ions that induce shocks in people and objects without any connection! Great science project as well as a high tech party prank. IOG3 Plans $8.00
IOG3K Kit/Plans $69.50

Invisible Pain Field Generator



Shirt pocket size electronic device produces time variant complex shock waves of intense directional acoustic energy, capable of warding off aggressive animals, etc.

IPG7 Plans .....$8.00 IPG7K Kit/Plans ...$49.50
IPG70 Assembled $74.50

1000 Ft++ Potato Cannon

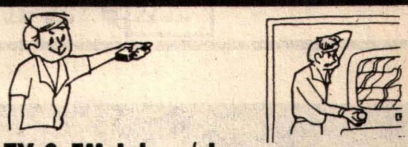
NOT A TOY. Uses electronic or piezo ignition. CAUTION REQUIRED!

POT1 Plans..... (Dangerous Product)..... $10.00

FireBall Gun

Shoots flaming ball - two shot capacity
Great for special effects and remote fire starting. CAUTION REQUIRED!

FIREBALL Plans (Dangerous Product).....$10.00



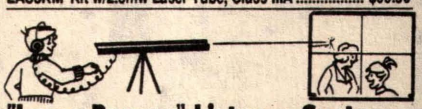
TV & FM Joker / Jammer

Shirt pocket device allows you to totally control and remotely disrupt TV or radio reception. Great gag to play on family or friends. Discretion required. EJK1KM Easy to Assemble Electronic Kit $24.50

Visible Beam Laser

High brightness red HeNe laser visible for miles.
Produce your own light show! Projects a visible beam of red lite clearly visible in most circumstances. Can be used to intimidate by projection of a red dot on target subject. Also may be used to "listen in" using our laser window bounce method #LLIS1 below. *Easy to build module makes A working visible laser!*

LAS1KM Kit w/1mw Laser Tube, Class II. $69.50
LAS3KM Kit w/2.5mw Laser Tube, Class IIIA $99.50



"Laser Bounce" Listener System

Allows you to hear sounds from an area via a lite beam reflected from a window or other similar objects. System uses our ready-to-use LATR1 Laser Terminator gun site as the transmitter. The receiver section is supplied as an easy-to-build kit, including our cushioned HS10 headsets. LLIST2 Plans $20.00
LLIST1K Kit of Both Transmitter and Receiver $199.50
LLIST20 Assemble with Laser Gun Site $299.50

3mw Visible Red Pocket Laser

Utilizes our touch power control!

VRL3KM Kit / Plans..... $74.50

Electronic Hypnotism

Puts subjects under control using highly effective electronic stimuli. Intended for parties and entertainment but must be used with caution. Includes valuable text book reference and plans.

EH2 Plans and Text Book $19.50

Pocket Sized Night Viewer

Uses Low Level Starlight to See in the Dark!

- Low Cost
- Ultra-Hi Lite Amplification!
- Auto Brightness Control
- Limited Amount Available
- Made in USA • Night surveillance • Animal studies, etc.

Can be used to fly an airplane or drive a car!

PKV7 Plans $15.00
PKV7K Easy to Assemble Kit ..... Price on Request
PKV70 Ready to Use ..... Price on Request

3 Mi FM Wireless Microphone

Subminiature! Crystal clear, ultra sensitive pickup transmits voices and sounds to FM radio. Excellent for security, monitoring of children or invalids. Become the neighborhood disk jockey, or go "under cover" using our sunglasses FM radio (see catalog). FMV1 Plans ... $7.00
FMV1K Kit and Plans $39.50
SUGL10 Sunglasses with built in FM Radio $29.50

Telephone Transmitter - 3 Mi

Automatically transmits both sides of a telephone conversation to an FM radio. • Tunable Frequency • Undetectable on Phone • Easy to Build and Use • Up to 3 Mile Range • Only transmits during phone use.

VWPM7 Plans $7.00
VWPM7K Kit/Plans $39.50

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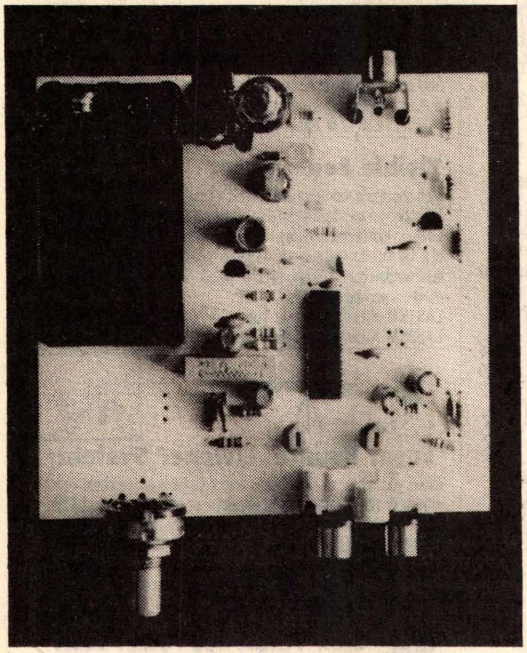


ALL NEW -- IMPROVED STEREO FM TRANSMITTER

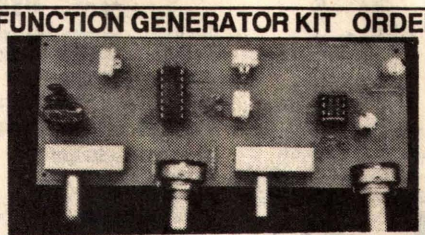
LOADED WITH FEATURES

* RF AMPLIFIER
* FRONT PANEL FINE TUNING
* STABLE OPERATION
* INPUT LEVEL ADJUSTMENTS
* WORKS WITH DIGITAL TUNED RADIOS
* 38KHz CRYSTAL MULTIPLEX CIRCUIT

DC'S all new FM Stereo Transmitter Kit based on the unique BA1404 Stereo Broadcaster Integrated Circuit that includes all the complex circuitry to generate the stereo signal. We've added an RF amplifier circuit to provided excellent transmit range. Additional features like electronic fine tuning, voltage regulation, 38KHz multiplex crystal, input level adjustment makes the Stereocaster the top of the line Stereo FM Transmitter.

ORDER STEREOCASTER $29.95

FUNCTION GENERATOR KIT ORDER FG2 KIT $19.95



A great project to enhance your bench. This handy little function generator has a built-in buffer amplifier, a 3-decade range selector switch that covers 15 hZ to 25 khZ, output level control and function switch to select sine, square, or triangle.

MAKE CIRCUIT BOARDS THE NEW, EASY WAY

WITH TEC-200 FILM

JUST 3 EASY STEPS:

- Copy circuit pattern on TEC-200 film using any plain paper copier
- Iron film on to copper clad board
- Peel off film and etch

convenient 8½ × 11 size
With Complete Instructions

ORDER TEC200-10 (10-SHEETS) $5.95

POWER SUPPLY KIT
PS-1 $16.99

Output of this power supply is continiously adjustable from 1.2 to 25V DC . The LM317T voltage regulator provides excellent regulation and ripple rejection. Includes a 1 A transformer, PC board, LM317T, 2 binding posts, and all small parts.

MORE KITS

3 DIGIT LED DVM ONLY 3" X 3" READS 0 TO 100 V DC ORDER DVM3 $19.95
FM WIRELESS BROADCASTER FMI $ 9.95
8038 FUNCTION GEN. KIT FGI $ 9.50
SEQUENCER PROJECT SEQKIT $ 9.50

CHRISTMAS TREE PROJECT

Build this unique seasonal project and have an unusual converstion piece. Powered by two D cells, 17 LEDs flash in a seemingly random fashon. Kit includes everything except batteries. ORDER XMASKIT $16.95

UNIVERSAL DECODER IC'S
REFER TO RADIO ELECTRONICS MAY 1990

CD22402E	7.95	CD4040	.6
LM733	.99	CD4053	.5
LM7805	.50	LM7812	.5
CA3126E	1.95	LM7905	.5
74C00	.50	3.58 MHz	1.0
NE564	2.29	18 Uh	.3

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NEW

2 Meter Amateur Transceiver

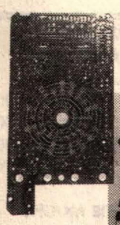
•5 Watt Transceiver •Tunes 144-148MHz •CTCSS/DTMF built in enabling code or tone squelch control as well as paging •Half duplex operation •20 Memory Channels •DTMF Code Decoding •Wide 5-16VDC Operation •Includes pack for "AA" Ni-Cad or alkaline batteries •Hi-Cap rechargeable battery, speaker mic and carry case available

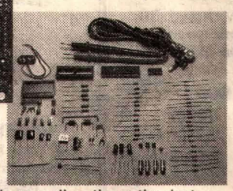
#111-4000 .....$279.95(1-2)

A wide range of 2 Meter and 440MHz Base Yagi and mobil single and dualband antennas are available!

TENMA®

The Worlds Most Affordable Test Equipment!





Digital Multimeter Kit

•Easy to build DMM great for schools as well as the enthusiast •3½ digit LCD display •Diode test •Measures AC/DC volts, DC amps and resistance to 2000K •Requires 9V battery MCM #290-080

#72-1035 .....$31.49(1-4)

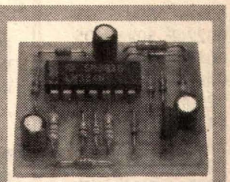
NEW

PCI Dual Display DMM

•This dual display multimeter is loaded with high–tech features including an RS-232 interface for viewing and storing data on a PC •Software and cable included •Call today for more information and complete specifications

#72-1050 ....$119.99(ea.)

MCM TECHKITS



Easy and fun to build. Creates useful circuits when completed. These are excellent educational tools for teaching the fundamentals of electronic circuits. All shown kits can operate on 9V battery. Call today for more information about these and other available kits.

Audio Amplifier

•Includes mini electret microphone •Ultra sensitive, can pick up sounds from across the room •Only 1" x 1¾"

#80-690 .....$10.95(ea.)

DMM Capacitance Adaptor

•Turn your Digital VOM into a capacitance meter •Measures 2.2µF - 2.2uF

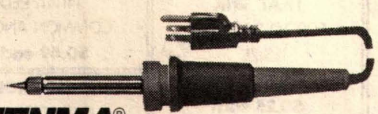
#80-695 .....$12.95(ea.)

Voice Activated Switch

•Sound activated switch can operate tape recorder, relay, lights and more •Only 1½" x 1¼"

#80-765 .....$6.95(ea.)

Prices effective thru June 17, 1994. Call for quantity pricing.

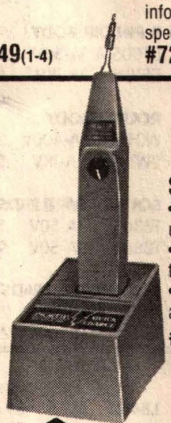


TENMA®

25W Grounded Soldering Iron

•Ideal for delicate or static sensitive work •Lightweight, with cool-grip handle •Replacement tips available

#21-940 .....$8.50(1-9)



ISOTIP® Cordless Soldering Iron

•Use in areas where AC is unavailable or inconvenient •Solders up to 125 connections on a single charge •Replacement battery and tips available

#21-130.....$49.95(ea.)

Solder Aid Kit

•Six piece kit includes heat sink, tweezers, probes and heat sink •Great for light work and kit building

#21-665 .....$3.95(1-9)

TENMA®

Rosin Core Solder

•High-quality small diameter solder •Low melting point great for small work

#21-1045 .....$4.25(1-9)

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6.8uF	25V	.04
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22uF	25V	.05
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47uF	25V	.06
100uF	25V	.08
220uF	25V	.08
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2200uF	25V	.42
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.0047uF	50V	.05
.01uF	50V	.05
.022uF	50V	.05
.047uF	50V	.05
.1uF	50V	.05
.22uF	50V	.12
.47uF	50V	.17

CERAMIC DISC CAPACITORS

10pF	50V	.05
22pF	50V	.05
27pF	50V	.05
33pF	50V	.05
47pF	50V	.05
68pF	50V	.05
82pF	50V	.05
100pF	50V	.05
120pF	50V	.05
150pF	50V	.05
180pF	50V	.05
220pF	50V	.05
270pF	50V	.05
330pF	50V	.05
470pF	50V	.05
1000pF	50V	.05
2200pF	50V	.05
3300pF	50V	.05
4700pF	50V	.05
.01uF	50V	.05
.022uF	50V	.05
.047uF	50V	.05
.1uF	50V	.05

DIPPED TANTALUM CAPACITORS

1uF	25V	.14
2.2uF	25V	.14
10uF	25V	.25
22uF	25V	.52

DIODES

1 AMP RECTIFIER

1N4001	50V	.03
1N4004	400V	.04
1N4007	1KV	.05

3 AMP RECTIFIER

1N5401	100V	.06
1N5404	400V	.07
1N5408	1KV	.08

6 AMP RECTIFIER

6A10	100V	.19
6A100	1KV	.22

1 AMP SCHOTTKY

1N5817	.20
1N5818	.23
1N5819	.25

3 AMP SCHOTTKY

1N5820	.40
1N5821	.46
1N5822	.50

GERMANIUM

1N34A	.10
1N60	.10
1N270	.17

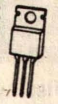
SWITCHING

1N914	.025
1N4148	.025

1 W ZENER DIODE

1N4728	3.3V	.07
1N4729	3.6V	.07
1N4730	3.9V	.07
1N4731	4.3V	.07
1N4732	4.7V	.07
1N4733	5.1V	.07
1N4734	5.6V	.07
1N4735	6.2V	.07
1N4736	6.8V	.07
1N4737	7.5V	.07
1N4738	8.2V	.07
1N4739	9.1V	.07
1N4740	10V	.07
1N4741	11V	.07
1N4742	12V	.07
1N4743	13V	.07
1N4744	15V	.07
1N4745	16V	.07
1N4746	18V	.07
1N4747	20V	.07
1N4748	22V	.07
1N4749	24V	.07
1N4750	27V	.07
1N4751	30V	.07
1N4752	33V	.07
1N4753	36V	.07
1N4754	39V	.07
1N4755	43V	.07
1N4756	47V	.07
1N4757	51V	.07
1N4758	56V	.07
1N4759	62V	.07
1N4760	68V	.07
1N4761	75V	.07
1N4762	82V	.07
1N4763	91V	.07
1N4764	100V	.07

TRANSISTORS



2N2222A	.22
2N3055	.65
2N3904	.05
2N3906	.05
2N4125	.09
2N4126	.09
2N4401	.05
2N4403	.05
2N5086	.09
2N5087	.08
2N5088	.08
2N5089	.09
2N5209	.09
2N5210	.09
2N5400	.12
2N5550	.12
2N5551	.09
MJE3055T	.65
MPSA-05	.10
MPSA-10	.12
MPSA-13	.15
MPSA-14	.15
MPSA-42	.14
MPSA-44	.22
MPSA-56	.10
MPSA-63	.45
MPSA-92	.10
MPSA-93	.15
MPSH-10	.10
PN2222A	.05
PN2907A	.05
TIP31	.42
TIP41	.48
TIP122	.52
TIP125	.55

VOLTAGE REGULATORS

7805	.48
7812	.48
7905	.48
7912	.48
78L05	.35
78L12	.35
79L05	.35
LM317T	.68
LM350T	2.05

INTEGRATED CIRCUITS

CD4001	.29
CD4011	.29
CD4013	.37
CD4017	.37
CD4028	.37
CD4049	.29
CD4051	.63
CD4066	.35
CD4069	.29
LM311	.43
LM324	.47
LM339	.47
LM358	.47
LM386	.67
LM393	.37
LM555	.43
LM556	.47
LM741	.37
MC1458	.43
LM1488	.47
LM1489	.47
TIL111	.35

IC SOCKETS

	LOW PROFILE	MACHINE SCREW	WIRE WRAP
8 PIN	.04	.16	.32
14 PIN	.08	.28	.56
16 PIN	.10	.32	.64
18 PIN	.11	.36	.72
20 PIN	.12	.40	.80
24 PIN	.15	.48	.96
28 PIN	.17	.56	1.12
32 PIN	.20	.64	1.28
40 PIN	.24	.80	1.60

DIP SWITCHES

4 POS.	.68
6 POS.	.77
8 POS.	.80
10 POS.	.95

TOGGLE SWITCHES

SPDT	.62
SPDT center off	.73
DPDT	.69
DPDT center off	.86

PUSH BUTTON SWITCHES

fits in a 1/4" hole

Normally open	.29
Normally closed	.30

BRIDGE RECTIFIER

IN LINE BODY

RS101	1A-50V	.60
RS106	1A-800V	.93
3N256	2A-400V	.95
TL400	4A-50V	.65
TU600	6A-50V	1.02
TU800	8A-50V	1.33

8 PIN DIP BODY

DF005M	1A-50V	.25
DF10M	1A-1KV	.52

ROUND BODY

W04M	1A-400V	.35
2W10M	2A-1KV	.50

SQUARE WIRELEADS

TB305	3A-50V	.53
TB805	8A-50V	.93

SQUARE TAB LEADS

TB151	15A-100V	2.30
TB352	35A-200V	2.68

CRYSTALS

HC18 case

1.8432	MHZ	.89
2.0000	MHZ	.74
3.5795	MHZ	.74
3.6864	MHZ	.74
4.0000	MHZ	.74
4.9152	MHZ	.74
5.0688	MHZ	.74
7.3728	MHZ	.74
10.000	MHZ	.74
11.000	MHZ	.74
11.059	MHZ	.74
12.000	MHZ	.74
14.3181	MHZ	.74

LED's

RED 3mm	.06
RED 5mm	.06
GREEN 3mm	.07
GREEN 5mm	.07
YELLOW 3mm	.08
YELLOW 5mm	.08

BLINKER LED

RED 5mm	.65

LED HOLDERS

3mm	.08
5mm	.08

CABLE TIES

NATURAL COLOR

4"	100pcs	2.00
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CABLE TIE MOUNT

self stick 100pcs 10.00

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$0.80 50pcs bag

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FOR TO-220 CASE SIZE

6/8" x 6/8" x 3/8"

$0.25 each

D-SUB CONNECTORS

SOLDER CUP

DB9 male	.29
DB9 fem.	.29
DB25 male	.53
DB25 fem.	.53

RIGHT ANGLE PC

DB-9 male	.39
DB-9 fem.	.39
DB-25 male	.69
DB-25 fem.	.69

PLASTIC HOOD FOR DB

DB-09	.26
DB-15	.27
DB-25	.29
DB-37	.53

FLOPPY DRIVE

1.44M 3.5"

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$34.00 each

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INCLUDES

- 2 HARD D. CONTR.
- 2 FLOPPY CONTR.
- 2 SERIAL PORTS
- 1 PARALLEL PORT
- 1 GAME PORT

$21.00 each

101 KEY KEYBOARD

1 YEAR WARRANTY

$19.00 each

FAX/MODEM BOARD

1 YEAR WARRANTY

WINDOWS SOFTWARE INCLUDED

$69.00 each

3 BUTTON MOUSE

DRIVERS SOFTWARE INCLUDED

$10.50 each

MOTHER BOARDS

386 CPU

DX-40	0K	138.00
DX-40	128K	150.00

486 CPU

SX-25	0K	233.00
DX-33	128K	487.00
DX-40	256K	546.00
DX-50		728.00

1Lb SOLDER ROLL

.031" diameter SN60/40

$6.50 each

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14mm RED COMMON ANODE

$0.49 each

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47uF	25V	.16
100uF	25V	.19
220uF	25V	.27
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2200uF	25V	.89

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5AR4/GZ34	6.90		5.90		5.40	MATCHLESS
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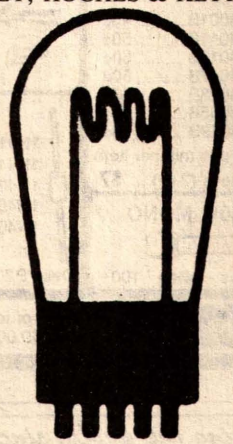

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12AX7a	3.35		2.45		2.20
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6550	9.90		8.90		7.90
KT88	10.90		9.90		8.90
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2K25	23.00 each	6AQ8	5.85 each	6CA4	4.90 each	6SJ7	2.90 each	12BY7	7.50 each
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(6BA6W industrial)		6AU6	2.25	6CX8	5.15	6SL7	2.90	12FQ8	9.00
5879	8.90	6AX5	4.90	6DR7	5.15	6SN7	2.50	35W4	4.90
5C22	46.50	6BA6	2.25	6EA8	5.50	6SQ7	3.50	7119	9.50
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5V4GT	1.90	6BH6	3.90	6FH8	14.50	6U10	5.50	50C5	4.90
6189W	4.15	6BK11	15.90	6GW8	6.90	6X4	4.45	811	9.70
(12AU7W industrial)		6BL8	2.90	6J5	5.00	6X5	3.90	813	23.00
6267/EF86	3.60	6BM8	5.00	6J7	5.50	6X8	3.90	0A2	3.90
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2N4401 ..... 6¢
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LM339 ..... 55¢
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NE556 ..... 60¢
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CD4013B ..... 50¢
CD4017B ..... 50¢

CD4028B ..... 50¢
CD4066B ..... 50¢
CD4069B ..... 50¢
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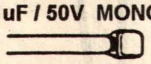
Deal 'V2': 14pcs (2 ea) $7

.1uF / 50V MONO

6¢ ea / 20pcs - 5¢ ea / 100+

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7805 ..... 75¢
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7824 ..... 75¢
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78L05 ..... 40¢
78L12 ..... 40¢
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MORE TRANSISTORS

2N2222A ..... 25¢

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No minimum quantity

DIODES

1N914A ..... 3¢
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1N4001 ... (1A/50V) .... 4¢
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1N4007 ... (1A/1kV) .... 6¢
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Deal 'P7': 50pcs (10 ea) .. $3

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1N5401 ... (3A/100V) ... 8¢
1N5404 ... (3A/400V) ... 9¢
1N5408 .... (3A/1kV) .. 10¢
6A20 ..... (6A/200V) . 22¢
6A100 ..... (6A/1kV) .. 25¢
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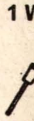
1N34A ..... 12¢
1N270 ..... 20¢
10 pcs min per item
Deal 'G3': 10pcs (5 ea) $2

1 WATT ZENER DIODE

1N4728A 3.3V
1N4733A 5.1V
1N4739A 9.1V
1N4742A 12V
1N4744A 15V
10¢ ea - 10pcs min - no mix.
Deal 'Z5': 25pcs (5 ea) $3

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Miniature size 1/4" Panel hole Solder Lugs
on-on ..... SPDT ..... 90¢
on-on ..... DPDT 1.00
on-off-on ..... DPDT 1.25
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I.C. SOCKETS
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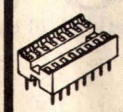
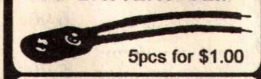

8 pin ..... 5¢
14 pin ..... 10¢
16 pin ..... 12¢
20 pin ..... 15¢
24 pin ..... 20¢
28 pin ..... 22¢
32 pin ..... 27¢
40 pin ..... 30¢
10 pcs min per item

SOLDER ROLL

SN63/37 - Multicore
21 Gage (.032" dia)
1 Lb roll - Great buy
$8.00 each

9V BATTERY CLIP

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68 PIN PLCC SOCKET

only..... **$1.00 each**

1/4W RESISTOR PACK

20 pcs of each:
1K, 4.7K, 10K,
47K, 100K, 470K
Deal 'W6'.... **$3.00**

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1uF/50V ..... 6¢
2.2uF/50V ..... 6¢
3.3uF/50V ..... 6¢
4.7uF/50V ..... 7¢
10uF/25V ..... 7¢
22uF/25V ..... 7¢
33uF/25V ..... 8¢
47uF/25V ..... 8¢
100uF/25V ..... 10¢
220uF/25V ..... 12¢
330uF/25V ..... 12¢
470uF/25V ..... 12¢
20 pcs min per item
Deal 'A9': 60pcs (5 ea) $5

TANTALUM CAPS

1uF/35V ..... 18¢
2.2uF/35V ..... 18¢
10 pcs min per item
Deal 'T6': 10pcs (5 ea)..... $3

CERAMIC DISC CAPS
6¢ each
(Caps rated 50V)

10pF	220pF
22pF	330pF
27pF	470pF
33pF	1000pF
47pF	.01uF
100pF	.1uF

20 pcs min per item
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Worlds smallest FM voice transmitter. Use with any FM broadcast receiver. Easy to assemble, all chip (SMT) parts are pre-assembled to the circuit board.
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- Smallest Phone transmitter anywhere!
- Tunes 88-108 MHz.
- No batteries required, powered by phone line.
- Up to 3/4 mile range.
- Attach to phone line anywhere in house, even inside phone.

XSP250 SUPER-MINIATURE PHONE TRANSMITTER
Worlds smallest FM phone transmitter. Use with any FM broadcast receiver. Easy to assemble, all chip (SMT) parts are pre-assembled to the circuit board.
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- Digital voice changing: male to female, female to male, adult to child, child to adult.
- 16 levels of voice masking.
- Button for normal operation.
- Complete anonymity on all calls

TRANSITION 2000 VOICE CHANGING TELEPHONE
STOP THOSE ANNOYING PHONE CALLS! Sound older and tougher when you want to. Not a kit, fully assembled. Single line phone operation only.
TRANSITION 2000 ..... $89.95

- Digital voice changing: male to female, female to male, adult to child, child to adult.
- Use with any modular phone.
- Connects between handset and phone.
- 16 levels of voice masking.

TRANSITION 2001 VOICE CHANGING Accessory
STOP THOSE ANNOYING PHONE CALLS! Sound older and tougher when you want to. Use with single or multi-line phones. Not a kit, full assembled.
TRANSITION 2001 ..... $59.95

- Transmits both sides of phone conversation.
- Adjustable from 88-108MHz.
- Works with any FM broadcast receiver.
- Up to 1 mile range.
- Turns off when phone is not in use to extend battery life.

XTT100 LONG RANGE PHONE TRANSMITTER
Similar to our very popular XSP500, the XTT100 is battery powered for maximum range. It plugs into any phone jack and transmits all calls on that line.
XTT100(C) Kit $32.95

- Super sensitive, hear every sound in a house!
- Powerful 2 stage audio amp.
- Use with any FM broadcast receiver.
- Up to 1 mile range.
- Powered by 9V battery.

XFM100 MINIATURE FM TRANSMITTER
The XFM100 has a super sensitive microphone and is capable of picking up sounds at the level of a whisper and transmitting them to any FM broadcast receiver.
XFM100(C) Kit $32.95

- Transmits a continuous beeping tone.
- Adjustable from 88-108 MHz.
- Up to 1 mile range.
- Works with any FM broadcast receiver.
- Operates at battery voltages of 3 to 18 volts.

XTR100 TRACKING TRANSMITTER
Measuring .7 by 2.4 inches, the XTR100 is ideal for use in locating lost model rockets, bicycles, automobiles, games of hide-and-seek, and contests.
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- Uses sensitive microwave transistor amplifier.
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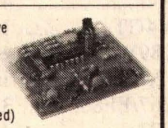
- Compact hand held unit.
- Uses Miniature loudspeaker (not included) for audio indication of detected signals.



XBD200 SUPER SENSITIVE BUG DETECTOR
When the XBD200 intercepts a signal in the 1 to 2000 MHz range, it emits a growl that increases to a high pitched squeal as the signal strength increases.
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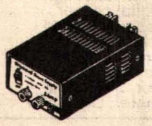

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6 AMP	$46.50
10 AMP	$79.50
20 AMP	$119.50
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Kit **$19.95**

Wired **$24.95**

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T-50-3	.55	FT50-77	.75
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T68-2	.75	FT82-68	1.00
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MAKE CIRCUIT BOARDS THE NEW, EASY WAY WITH TEC-200 FILM

JUST 3 EASY STEPS:

- Copy circuit pattern on TEC-200 film using any plain paper copier
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Convenient 8 1/2 x 11 size
With Complete Instructions

5 SHEETS	$6.25
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"COMMUNICATE WITH THE WORLD THROUGH HAM RADIO" is a complete Novice Training package. It contains a 14 lesson theory course and a Novice code cassette that teaches how to send and receive code up to 8 WPM and a 32 page book.

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NP-1 ..... **$10.95**

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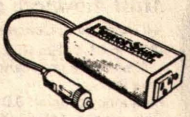
Double balance Mixer
LO/RF - 1-500MHz
RF DC - 500 MHz

$6.75

200 WATT INVERTER

Plugs into your lighter and runs:



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- Power Tools
- Shaver
- 13" TV with VCR
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Output:	**115 volts AC true RMS**
Power:	400 Watts peak
	200 Watts for 2 minutes
	140 Watts continously
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Weight:	15 ounces
Warranty:	3 year

$99.95

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DIGITAL LCR METER measures inductance, capacitance and resistance. At Last! An LCR meter that everyone can afford. Now you can measure coils, transformers, chokes from 1µH to 200H. Capacitors from .1 pfd to 200 mfd and resistors from .1 ohms to 20 meg ohms. All in one handheld instrument.

MODEL LCR-1801 ..... **$119.95**

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1-1/2" Diameter 0-100 Marking **$9.25**
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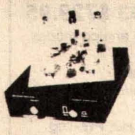
SIGNETICS NE602AN

Balanced Mixer/OSC. Popular IC among experimenters for building DC and super-het receivers.

$2.49 ..... BUY 3 OR MORE ... $2.25

SHORTWAVE CONVERTER KIT



Bring some interest to those long commutes to and from work, this shortwave converter is the ticket. The SC-1 converter brings the sounds of the world right into your car radio or home stereo (set to AM broadcast band). Front panel push switch lets you choose between regular AM radio between any two bands of interest, each 1 MHz wide. Set one range for daytime frequencies and one for night time when propagation is different, choose any two frequencies between 3 and 22 MHz.

Frequencies are tuned on your AM radio, making it easy to log stations or set presets. Built-in antenna switch automatically switches existing AM antenna to either the radio or converter, making hook-up easy. A handsome matching case and knob set puts the finishing touches on your kit.

SC-1 ..... **CONVERTER KIT** **$27.95**
CSC ..... **MATCHING CASE SET** **$12.95**

SIGNAL INJECTOR/ TRACER KIT

This handy tester is both a signal generator and receiver. As a generator use it to check out an amplifier, stage by stage. Also tests AM radio IF and RF stages. As a receiver you can pin point where a defective part exists. Will transmit and receive simultaneously.

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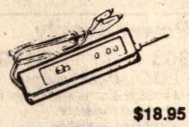
Hand held Digital Logic Probe provides convenient and precise use in the measurement of logic circuits. It displays logic levels (high or low), pulses and voltage transients down to 300 nanoseconds. High intensity LED readouts provide instant response to the logic state.



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- Built in 5V power supply
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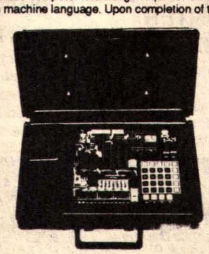

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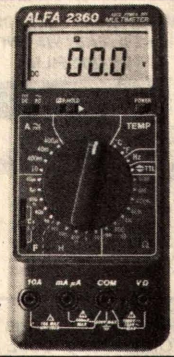

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Capacitance: 1pF-40µF
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Volt, Amp, Ohm
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Peak Hold
Auto power off
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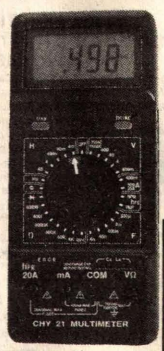

DMM 21 $74.95

Inductance: 1µH-40H
Capacitance: 1pF-200 F
Frequency: 1Hz-1MHz
Volt, amp, ohm, diode, continuity
3999 count display
TTL logic, HFE
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Full line of DMMs, economy, compact, ruggedized, solar cell, automotive, heavy duty, industrial, starts from $15.95

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Fluke 83	$225
Fluke 85	$259
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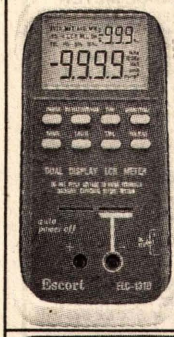

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Most Advanced LCR

Dual display:L/Q or C/D
Inductance: 0.1µH-1000H
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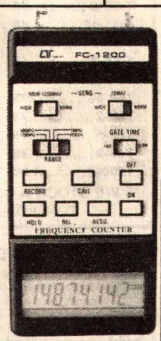
Impedance:1mΩ-10MΩ
0.7% basic accuracy
Dissipation factor & Q factor
Serial & parallel mode
Relative mode for comparison and to remove parasitics
Statistics, tolerance,
Best for design, incoming testing & production
SMD and chip component test probe $25.00

LCR Meter 814 $189.95

Best Resolution LCR

Inductance: 0.1µH-200H
Capacitance: 0.1pF-20,000µF
Resistance: 1mΩ-20MΩ
1% basic accuracy
Dissipation factor indicates leakage in capacitor and Q factor in inductor
Zero adjustment to reduce parasitics from test fixture
Best for high frequency RF and surface mount components.
SMD and chip component test probe $25.00, Deluxe carrying case $5.00



Frequency Counter FC-1200 $129.95

Frequency:0.1Hz-1.25GHz
Display: 8 digit LCD
Period: 0.1µs-0.1s
Records Max/Min/Average
Data hold, relative mode
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Also Available:
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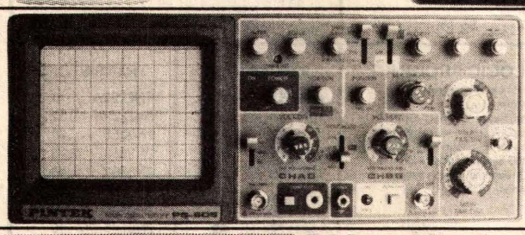

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Dual Trace, Component test, 6" CRT, X-Y Operation, TV Sync, Z-Modulation, CH2 Output, Graticule Illum, 2 probes each has x1,x10 switch. Best price with delay sweep.

PS-200 20 MHz DUAL TRACE	$339.95
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Scope Probe: 60MHz x1, x10 $13, 100MHz x1, x10 $22

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2 K word per channel storage
Sampling rate: 10 M sample /sec
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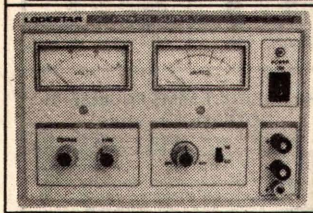
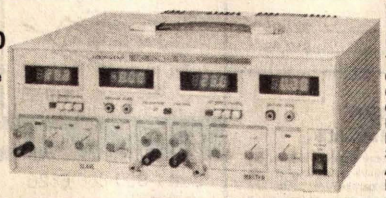
Refresh, Roll, Save all , Save CH2, Pre-Trig
Plotter Control
250MHz x1, x10 $29, 250MHz x100 $39



DC Power Supply PS-303 $159.00

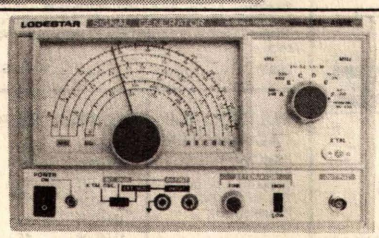
0-30 VDC , 0-3A output

Constant voltage & constant current mode
0.02% + 2mV line regulation
0.02% + 3mV load regulation
1 mVrms noise and ripple
Short circuit and overload protected
PS-8200 with digital voltmeter $179.00
Also available: 30V/5A, 60V/3A, 60V/5A
16V/10A, 30V/10A



DC Power Supply Triple Output PS-8202 $499.95

Two 0-30 VDC , 0-3A outputs
One fixed 5VDC, 3A output
Capable of independent or tracking operation
Constant voltage and constant current mode
Four digital meters for volt and current display
Excellent regulation and low ripple
Short circuit and overload protected
Also available: 30V/5A triple output $549.95
Dual tracking 30V/3A, 30V/5A, 60V/3A, 60V/5A



RF SIGNAL GENERATOR SG-4160B $119.00

100 kHz-150MHz sinewave in 6 ranges
RF Output 100mVrms to 35 MHz
Internal 1kHz, External 50Hz-20kHz
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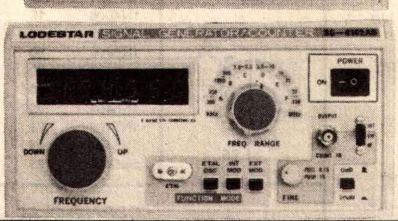

RF SIGNAL GEN./COUNTER SG-4162 AD $229.95

Generates RF signal same as SG-4160B
Frequency counter 1Hz - 150 MHz for internal and external source
Sensitivity <50mV

AUDIO GENERATOR AG-2601A $119.00

10Hz - 1MHz in 5 ranges
Output: 0-8Vrms sinewave
0-10Vp-p squarewave
Synchronization: ±3% of oscillation frequency per Vrms
Output distortion:
0.05% 500Hz - 50kHz
0.5 % 50Hz - 500kHz
Output impedance: 600 ohm

AUDIO GEN./COUNTER AG-2603AD $229.95

Generates audio signal same as AG-2601A
Frequency counter 1Hz-150MHz for internal and external sources
Sensitivity <50mV

FUNCTION GENERATOR FG-2100A $169.95

0.2 Hz -2 MHz in 7 ranges
Sine, square, triangle, pulse and ramp
Output: 5mV-20Vp-p
1% distortion, DC offset ± 10V
VCF: 0-10V control frequency to 1000:1

FUNCTION GEN/ COUNTER FG-2102AD $229.95

Generates signal same as FG-2100A
Frequency counter 4 digits
Feature TTL and CMOS output

SWEEP FUNCTION GEN./COUNTER $329.95

0.5Hz to 5 MHz in 7 ranges
Sweep: Linear 10:1/Log 10:1 20ms to 2s
AM Modulation
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Generator Control Voltage & 6 digit counter
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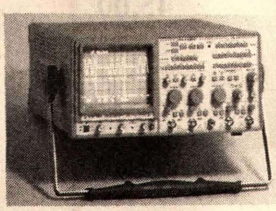
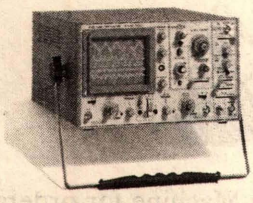
100 MHz Cursor Readout Scope
4 ch, 8 traces OS-6101 $1,499.95



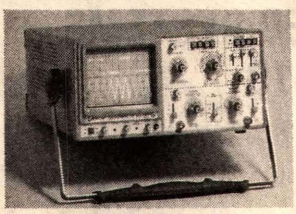
* 4 independent channels, 8 traces
* Time /Voltage cursor measurement
* ALT triggering function for 4 ch.
* Sweeps to 2ns/div, Delayed Sweep
* TV Sync., Ch. 1 output, Z-axis input
* 2 probes(x1, x10)

100 MHz Scope, 4ch. 8 traces
Best value all purpose scope
OS-6100B $1,329.95



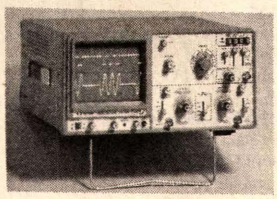
* 4 channels, 8 traces
* High sensitivity 500μV/div
* Sweeps to 2ns/div, Delayed sweep
* 20 kV accelerating voltage
* TV sync., Z-axis input
* A and B gate output
* Best price 100 MHz scope
* 2 probes(x1, x10)

50 MHz Triggering Oscilloscope
OS-653 $699.95



* Dual Channel
* Hold Off Function
* Delayed Sweep
* Built-in Delay Line
* TV Sync
* ALT Triggering
* High sensitivity 1 mV/div
* Trigger level lock function
* Z-axis input, CH1 output
* 2 probes(x1, x10)

20 MHz Oscilloscope
OS-622B $344.95



* Dual trace, X-Y operation
* TV Sync., Z-axis input,CH 1 output
* High sensitivity 1 mV/div
* Trigger level lock
* 2 probes (x1, x10)

OS-645B - 40 MHz Cursor readout.....$ 734.95
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Single Output

* Constant voltage and constant current mode
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* Current regulation ≤0.2%
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* Overload and reverse polarity protection
* Features 2 analog or 1 digital meter(PS series)
  2 analog or 2 digital meters(PR series)

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PS-1850 : (0-18V, 0-5A).....$204.95
PS-1850D : Digital Display.....$229.95
PS-3225 : (0-32V, 0-2.5A).....$199.95
PS-3225D : Digital display.....$219.95
PS-6010 : (0-60V, 0-1A).....$199.95

PR-1810H : (0-18V, 0-10A).....$329.95
PR-3060 : (0-30V, 0-6A).....$299.95
PR-6030 : (0-60V, 0-3A).....$299.95
PR-6030D : Digital Display.....$399.95

Triple Output DC Power Supplies

* Two variable 0-30VDC, 0-3A outputs
* One fixed 5VDC, 3A output
* Auto tracking
* Auto serial and parallel operation
* Constant voltage and constant current mode
* Continuous/dynamic load can be selected
* Features 4 analog or 2 digital displays

PC-3030 : (0-30V, 0-3Ax2).....$479.95
PC-3030D : Digital display.....$509.95

Programmable DC Power Supplies

* High stability , low drift, 4 digit display
* Front/rear output-sense switch selectable
* Auto step running w/timer settings
* 100 point programmability (PPS series)
* 50 point programmability (PPT series)
* Auto serial and parallel operation (PPT series)
* Auto tracking (PPT series), IEEE-488.2 and SCPI compatible command set (optional)

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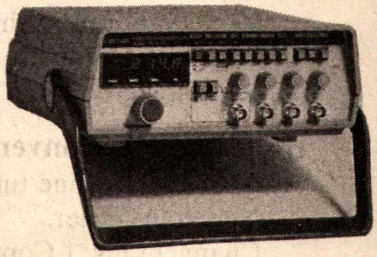
PPS-3635G: (0-36V, 0-3.5A).....$999.95
PPS-6020G: (0-60V, 0-2A).....$999.95
PPT-1830G: (0-18V, 0-3Ax2, 0-6V, 0-5A).....$1299.95
PPT-3615G: (0-36V, 0-1.5Ax2, 0-6V, 0-3A).....$1299.95

Digital Display Function Generator
FG-8016G $239.95



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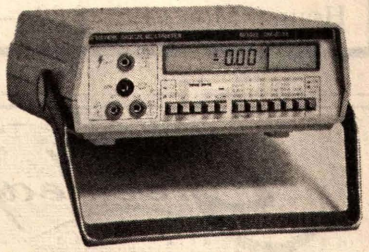
* Three Instruments in one: Function generator, Pulse generator & Frequency counter.
* Sine, Triangle, Square, TTL Pulse and CMOS output
* Built-in 6 digit counter with INT/EXT function
* 1000:1 tuning range
* Variable DC offset control

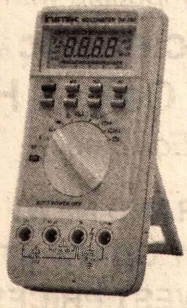
FG-8015 Function Generator
* 0.02Hz-2MHz (No Counter).....$189.95
FC-8131 Intelligent Counter 1.3GHz.....$469.95
FC-8270 Intelligent Counter 2.7GHz.....$599.95
UC-2010G Universal Counter.....$289.95

Digital Multimeter & C Meter
DM-8034(3½ digits) $179.95



* 8 Function, AC/DC voltage, AC/DC current, resistance
* Built-in C meter, diode test and audible continuity check
* High voltage 1000V and 20A range
* 0.5% basic accuracy

DM-8040 (3¾ Digits, True RMS)
* Measures ACV to 50 kHz.....$339.95
DM-8055 (5½ Digits).....$649.95
* 0.006% basic accuracy
* 1μV, 1mΩ, 1nA resolution
* dBm measurement
* Auto range, relative mode, Max/Min
DM-8055G(5½ Digits, GPIB).....$889.95



Model DM-392
(3¾ digits) $109.95

* Auto/Manual ranging(38 ranges)
* 42 Segment analog bar graph
* Data Hold/Min-Max memory /Relative mode
* Auto power off
* Overload protection
* Audible continuity check /diode test
* Capacitance: 1pF-40μF
* Frequency: 0.1Hz-1MHz
* 20 Amp range
* Double high energy fused (1A, 20A)
* 0.3% DCV accuracy
* **AC True RMS** (DM-394 only)

DM-351 : 3½ Digits w/Continuity, Auto Off.....$54.95
DM-352 : 3½ Digits, Cap. Freq. hFE, 20 Amp.....$79.95
DM-353 : 3½ Digits, Cap. Freq. Temp. hFE.....$84.95
DM-391 : 3¾ Digits, Auto, Cap. Freq. Min/Max....$99.95
DM-392 : 3¾ Digits, Hold, Min/Max 20Amp.....$109.95
DM-393 : 3¾ Digits, Peak, Logic, hFE, Freq.....$119.95
DM-394 : 3¾ Digits, TRMS, Same as DM 392....$129.95

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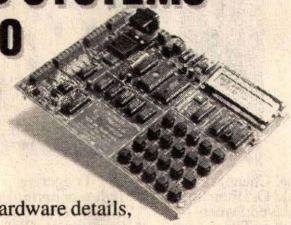

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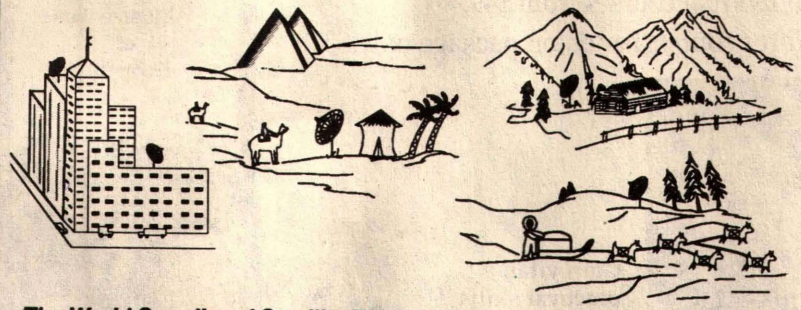

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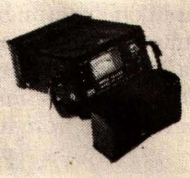

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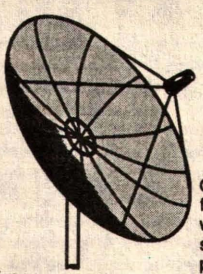

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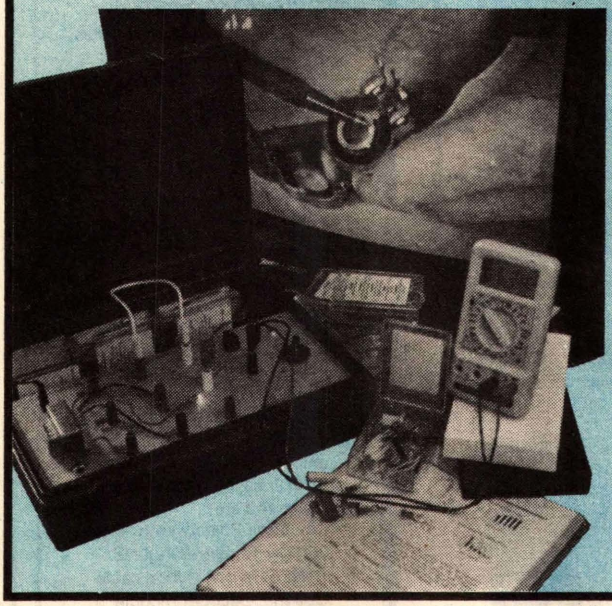

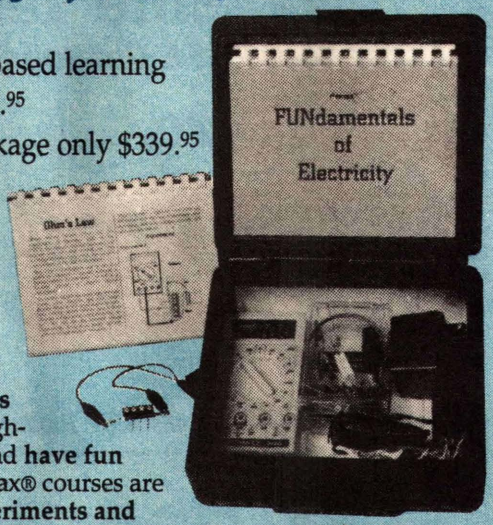

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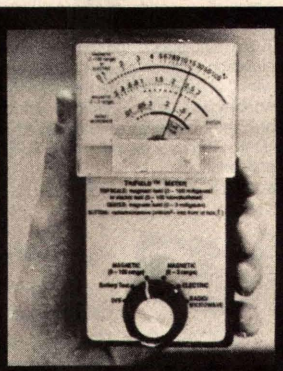

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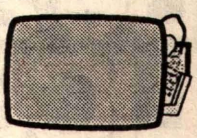

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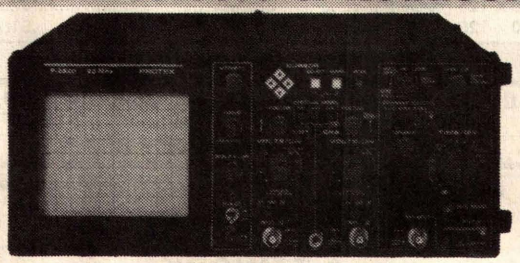

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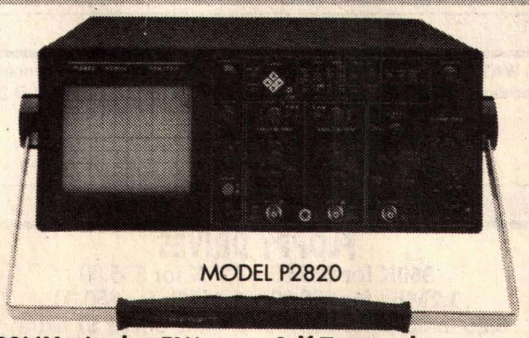

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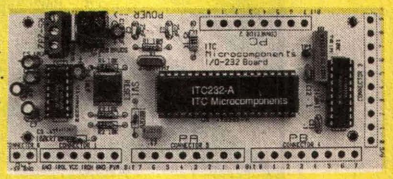

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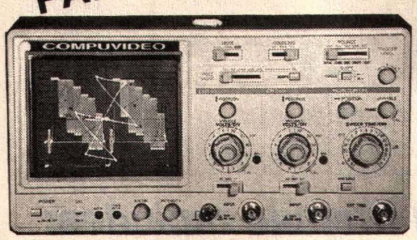

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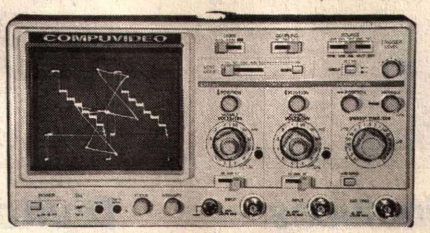

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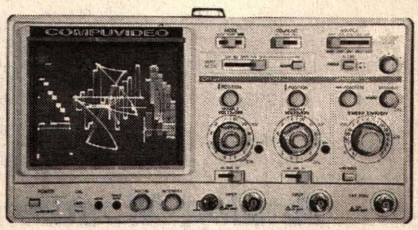

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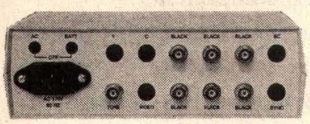

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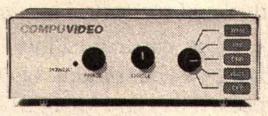

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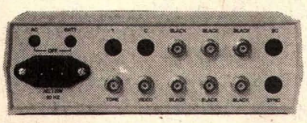

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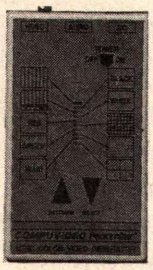

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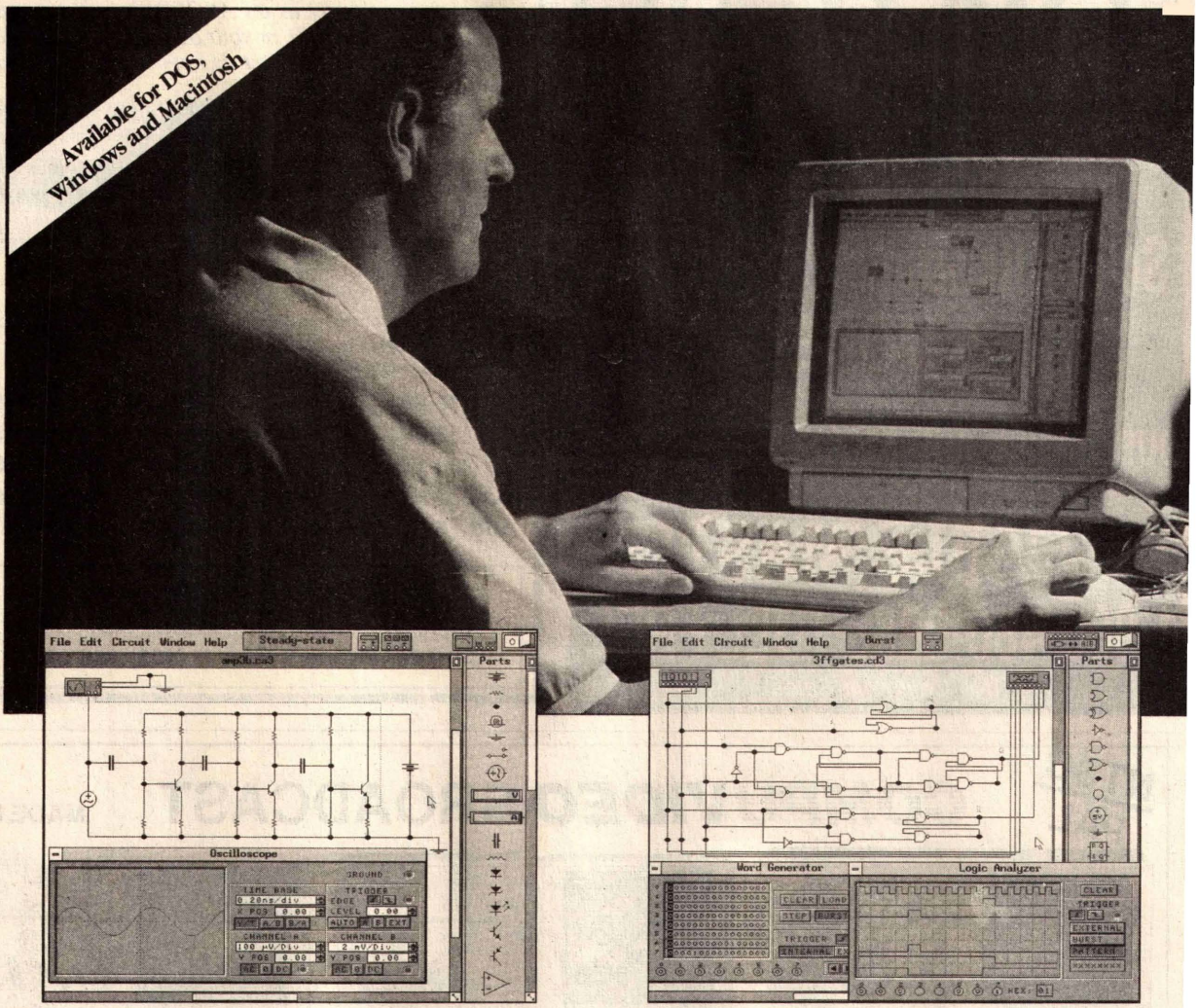

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Windows version: MS-DOS 5.0 or higher, Microsoft Windows 3.1, 2 MB RAM with suitable pointing device.

Macintosh version: Macintosh Plus or higher, 2 MB RAM, System 6 or 7.

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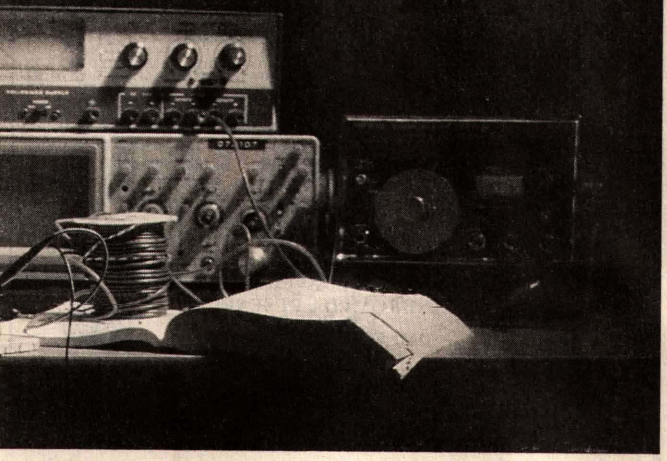

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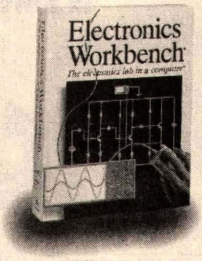

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LASERCOMS

Communicate high quality audio or data on an IR laser beam. Circuitry employs FM techniques with a 200KHz carrier. The kit includes two PCBs (transmitter and receiver), all the on-board components, an electret microphone, a speaker, a 5mW–780nM laser diode, a suitable collimating lens, and the instructions. That's everything you need to make a high quality IR laser communications link which has been tested to over 300 metres. An optional relay (12V) makes this unit double up as a perimeter protection system. Relay activates when the beam is broken.

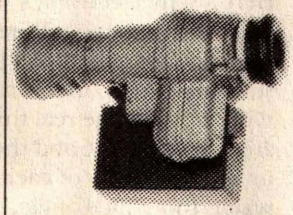
$39

A similar kit which does not include the laser diode and the collimating lens, but is supplied with an IR LED instead, is also available. This kit produces identical results over a much shorter range of 3-4 metres. All that is necessary to demonstrate communications on a light beam, a light beam relay, and "fibre optic" cable communications. Fibre optic cable is not supplied.

$23

12V relay suitable for use with either of the above: $2 extra.

PASSIVE NIGHT VIEWER



This kit is based on a BRAND NEW monocular night vision scope which is completely assembled and requires an EHT power supply. The EHT power supply is provided in kit form, and is easy to build. The scope employs a high gain passive first generation image intensifier tube which is made in Russia. It will produce useful images in sub-moonlight illumination, and can be IR assisted in total darkness.

$240

Available "Ready made" for an additional $50

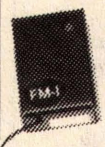
IR BINOCULARS

HELMET NOT INCLUDED

High quality helmet mount, ex-military binocular viewer. Will stretch and clip over most military and some lightweight constructors helmets. Note that the helmet is not provided. Self powered by one 1.5V, "C" size battery. Adjustable eyepiece and focus: from 1 metre to infinity. Requires IR illumination. Limited stocks, at a CLEARANCE PRICE OF:

$220

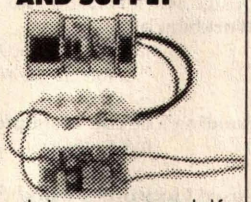
MINIATURE FM TRANSMITTER



Not a kit, but a very small ready made self contained FM transmitter enclosed in a small black metal case. It is powered by a single small 1.5V silver oxide battery, and has an inbuilt electret microphone. Specifications: Tuning range: 88-108MHz; Antenna: Wire antenna — attached; Microphone: Electret condenser; Battery: One 1.5V silver oxide LR44 / G13; Battery life: 60 hours; Weight: 15g; Dimensions: 1.3" X 0.9" X 0.4".

$26

INFRA RED TUBE AND SUPPLY



These are the key components needed for making an INFRA RED NIGHT VIEWER. The tubes will convert infra red light into visible light on the phosphur screen. These are prefocussed tubes similar to type 6929. Do not require a focus voltage. All that is needed to make the tube operational is a low current EHT power supply, which we provide in kit form. Draws 20mA from a small 9V battery. INCREDIBLE PRICING:

$60

For the image converter tube and an EHT power supply kit! All that is needed to make a complete IR night viewer is a lens, an eyepiece, a 9V battery, a case and a switch. We may have available some low cost lenses and ready made power supplies to suit.

INFRA RED FILTER

A very high quality IR filter and a RUBBER lens cover that would fit over most torches including MAGLITEs and covert them to a good source of IR. The filter material withstands high temperatures and produces an output which would not be visible from a few metres away and in total darkness. Suitable for use with passive and active viewers.

$11

For the filter and the rubber lens cover.

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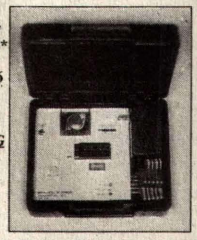

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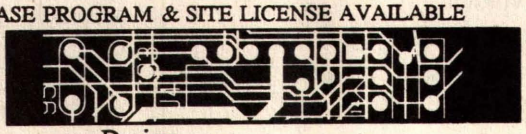

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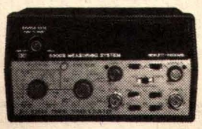
Fluke 8022B
Digital Multimeter
$99

The 8022B is a pocket-size digital multimeter that is ideally suited for application in the field, lab, shop or home. This meter offers all standard VOM measurement functions including AC & DC Volts, Alternating and Direct current, and resistance. Features include a high contrast 3 1/2-digit LCD display, that can be easily read from across the room, no need to worry about bent needles, parallax, etc. Each range has full auto-polarity operation, overrange indication, and effective protection from overloads and transients. Long term calibration stability- 2 years. Easy calibration- few adjustments. DCV: 200 mV to 1000 V f.s.; ACV: 200 mV to 750 V f.s. (45 Hz to 450 Hz); AC & DC current: 2 mA to 2000 mA f.s.; Resistance: 200 Ω to 20 MΩ f.s.

Hewlett Packard 466A
AC Amplifier
$159

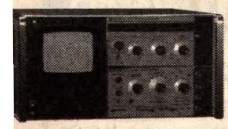
The 466A is a highly stable, low-distortion, wide range amplifier. Excellent for audio, ultrasonic or low RF measuring. Provides gain of 20 dB (x10) or 40 dB (x100) with an accuracy of ±0.2 dB at 1000 Hz. Frequency response: ±0.5 dB, 10 Hz to 1 MHz down 3 dB; or less at 5 Hz and 2 MHz. Output voltage: 1.5 V rms across 1500 Ω; 1 mA maximum. Input impedance of 1 MΩ.

Hewlett Packard 5300B/5308A
Universal Timer/Counter System
$495



The HP 5300B/5308A system provides for frequency, period, period average, time interval, time interval average, totalize and ratio measurements. Two inputs are provided and cover the frequency range of DC to 75 MHz. Sensitivity is rated at 25 mV rms (10 MHz) and 50 mV rms to 75 MHz. The display unit provides reference frequency, 8-digit/7-segment display, counting logic and timing control, an external timebase input is also provided. An exceptional value on this counter system!

Hewlett Packard 141T/8552B/8553B
Spectrum Analyzer
$2495



The HP 141T based spectrum analyzer features absolute calibration of frequency and amplitude, high resolution and sensitivity, wide dynamic range, and simple to interpret display output. The 141T mainframe features an easy to read 8 x 10 cm variable persistence CRT with a writing rate from 0.2 sec to 15 sec. Maximum storage time is over 2 hours at reduced brightness. The 8552B/8553B IF and RF sections feature a tuning range from 1 kHz to 110 MHz, with 18 calibrated scan widths from 20 Hz/div to 2 MHz/div in a 1, 2, 5 sequence. Amplitude range is from -140 to +30 dBm. Bandwidths are adjustable from 10 Hz to 300 kHz.

Tektronix 851 Digital Tester
$249

Auto ranging DMM with a 4 1/2-digit multimeter, floating inputs and a 500 VDC (350 VAC) max. input. Auto ranging, 5 digit, 35 MHz universal counter with three inputs and an accuracy of ±0.005%. Calibrated gated square wave output at 5 kHz and three channels feature -30 to +30 V threshold adjustments

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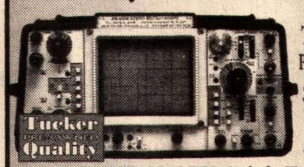

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SPECIFICATIONS:
Vertical Section:
- Bandwidth: DC to 100 MHz with or without probe
- Bandwidth limit mode: bandwidth limited to 20 MHz
- Rise time: 3.5 nS or less
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- Max. Input Voltage: ±250 VDC peak AC at 50 Hz
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- Time Base A: 0.5 S/div. to 0.05 μS/div. in 22 steps (1-2-5 sequence). X10 magnifier extends fastest sweep rate to 5 nS/div.
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- Horizontal Display Modes: A, A intensified by B, B delayed by A, mixed

Sweep Section:
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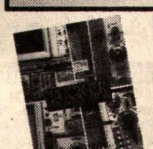

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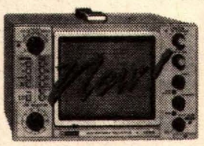

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Logimetrics 920-S101
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$495

The 920-S101 is a solid-state instrument, used for generating accurate CW, amplitude modulated, or frequency modulated signals over the 11 MHz to 80 MHz frequency range (three over-lapping ranges). Easy-to-use, front-panel is logically designed so that quick setups are possible even with inexperienced users. Internal 1 kHz or external signal may be used for AM modulation. In the FM mode, signal may be modulated by an internal 1 kHz signal or by an external 50 Hz to 10 kHz signal. Calibrated output signal in 10 dB steps from -110 dBm to +10 dBm. Both Amplitude and Modulation are displayed using large, easy-to-read meters.

Military USM390
Signal Generator
$895

This late model, solid-state Signal Generator can fulfill many applications by providing calibrated test signals at any frequency from 1 to 1000 MHz. CW, Sine, Square, and Pulse outputs are available with output level continuously variable over an 80 dB range (-70 dB to +10 dB). A whip antenna is also furnished for use in checking radio receivers. This unit will operate from either 115 or 230 VAC (50-400 HZ) or an internal 28 V battery for field use. To protect during transportation and storage, the USM 390 is enclosed in a rugged , waterproof carrying case with cover.

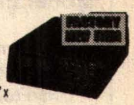
Icom IC-R1
.1-1300 MHz Handheld Communications Receiver
$479

The IC-R1 is the ultimate in miniaturization in a hand-held communications receiver and our best seller! It covers 100 kHz to 1300 MHz continuously (no gaps) with AM, FM and Wide FM modes. Features include: 100 memory channels, several scanning modes, sleep timer, low battery indicator, and several battery power options (listed below). Comes complete with wall charger, flexible antenna and belt clip. The built-in internal NiCad battery lasts about 3 to 4 hours, the various battery options below last much longer (BP-84 10 to 12 hrs.) Measures only 1.9" x 4" x 1.4" and weighs only 9.9 oz.

AOR AR1500XLT
1000 Channel Continuous Coverage Receiver
$459

Continuous coverage of .5 to 1300 MHz (no gaps). Features include: lock-out search and scan, cigarette lighter plug cord, belt clip, case, flex antenna, and earplug. Covers AM, W/N FM, and SSB. VFO knob or keypad. 6.7" x 1.4" x 2.6", 10 oz.

AOR AR2800
.5 to 1300 MHz Scanner
$459



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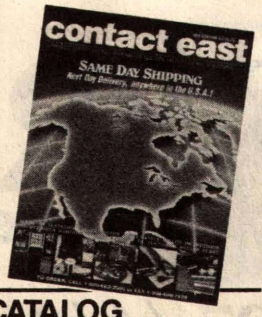

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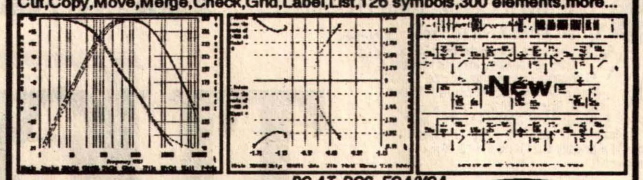

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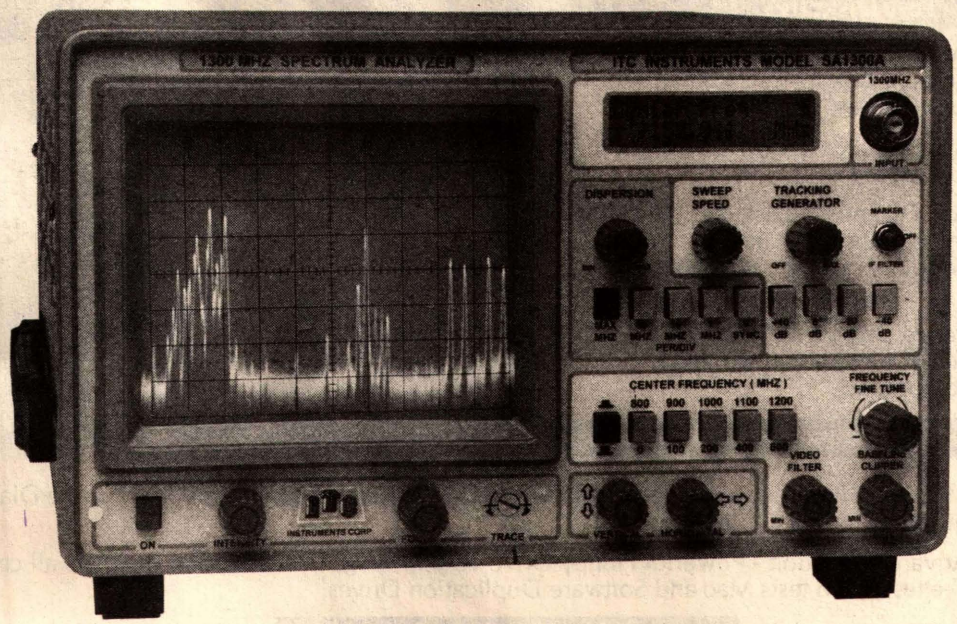

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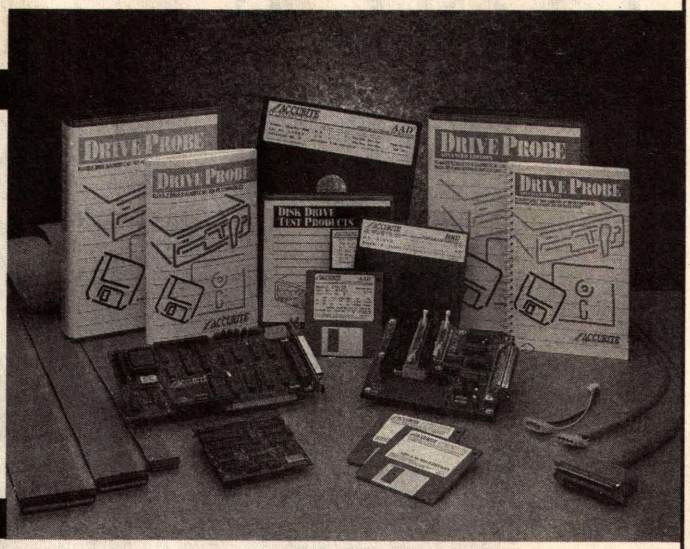

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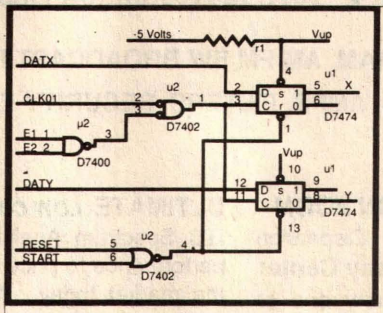

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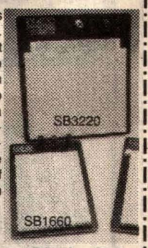

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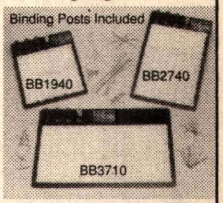

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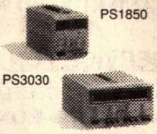

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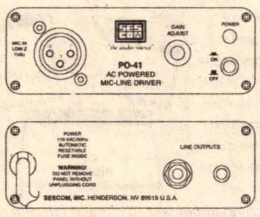

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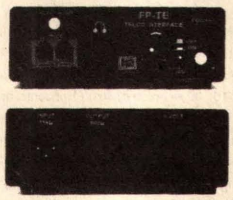

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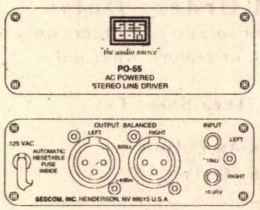

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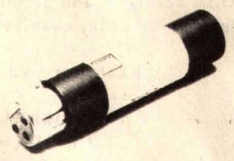

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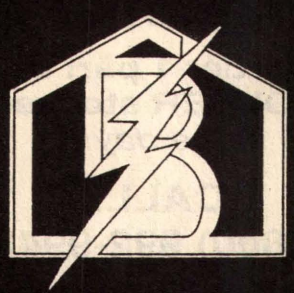

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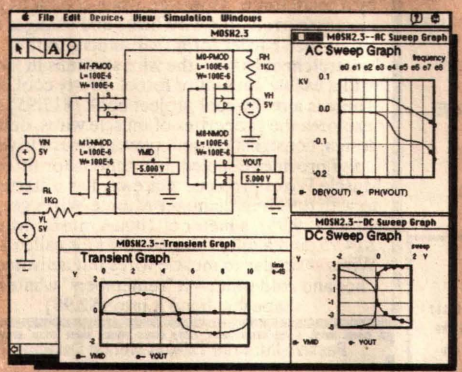

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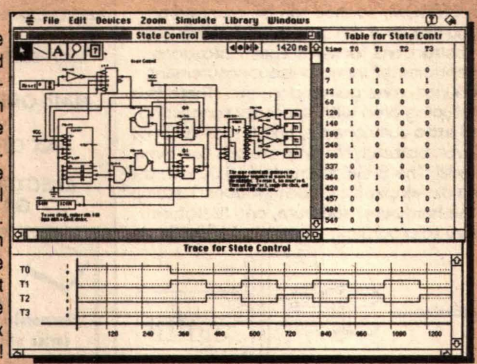

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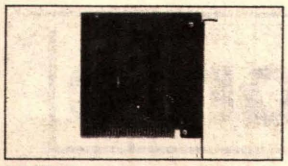

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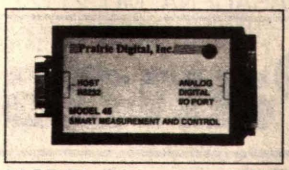

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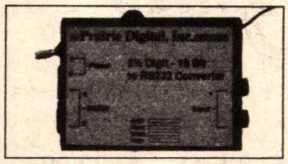

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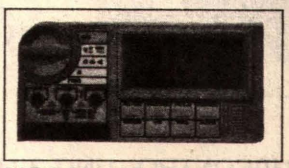

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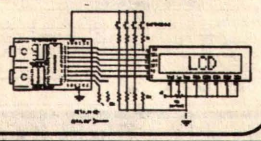

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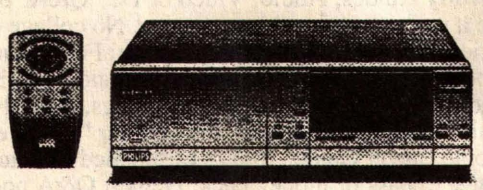

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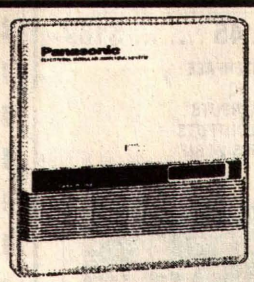

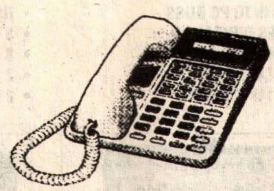

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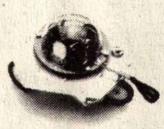

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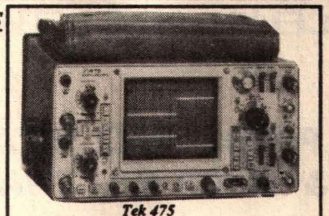

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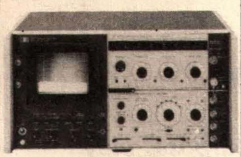

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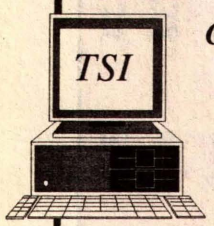

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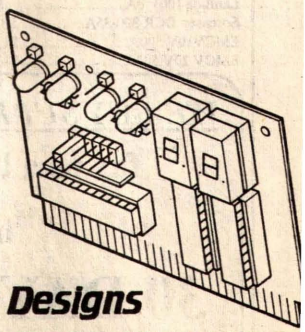

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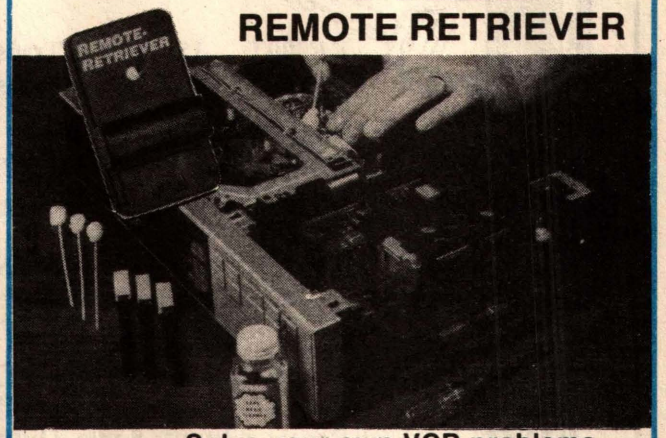

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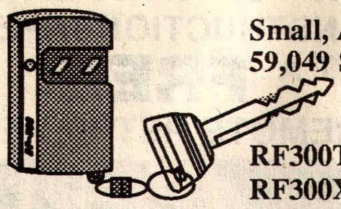

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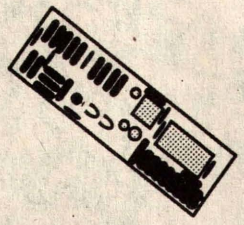

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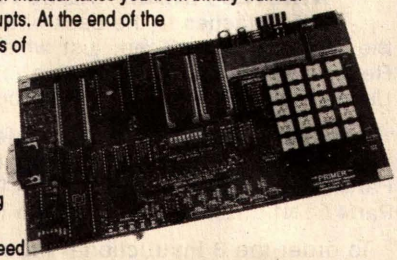

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HP 3336B Synthesizer/Level Gen., 75 ohms $650.00
HP 3336C Synth./Level Gen.,10 kHz-21 MHz $1250.00
HP 3575A-opt002 Gain-Phase Meter, 1 Hz-13 MHz $1000.00
KROHN-HITE 3202R Dual HP/LP/BP/BR Filter,to 2 MHz $500.00
P.A.R. 189 Filter/Amplifier, 0.1 Hz-110 kHz $350.00
ROCKLAND 752A-opt.02 Dual Low Pass Filter, 115 dB/oct $1100.00
TEK AM502 Differential Amplifier $575.00

RF & MICROWAVE

ANRITSU MS2601A Spectrum Analyzer, 10 kHz-2.2 GHz HP 5371A Modulation Domain Analyzer $6900.00
HP 8443A Tracking Generator, 0.1-110 MHz $5900.00
HP 8444A-opt059 Tracking Generator, 0.5-1500 MHz $500.00
HP 8552B IF Section $1500.00
HP 8553B RF Section, 1 kHz-110 MHz $750.00
HP 8554B RF Section, 0.1-1250 MHz $500.00
HP 8555A RF Section, 0.01-18 GHz $800.00
TEK 1401A/323 Portable Spectrum An., 1-500 MHz $950.00
TEK TR503 Tracking Generator, 0.1-1800 MHz $900.00
HP 8405A Vector Voltmeter, 1-1000 MHz $1750.00
NARDA 7000A Microwave Multimeter, 0.1-18 GHz $700.00
WAVETEK 1038N10/D14A Scalar Network An.,1 MHz-26.5GHz $1950.00
WILTRON 63A50-opt.1 VSWR Autotester, 10-4000 MHz $1250.00
BOONTON 102C Signal Generator, 0.45-520 MHz $600.00
HP 11720A Pulse Modulator, 2-18 GHz $850.00
HP 8640B-323 Signal Generator, 0.5-512 MHz $1200.00
HP 86631B External AM/Pulse Mod., for 8660 ..... $750.00
MARCONI 2019A Synth. Signal Gen., 1.5-1040 MHz $250.00
WILTRON 6742A-opt.01 Synth. Sig./Swp. Gen., 18-40 GHz $3500.00
EIP 928-opt.9201 Programmable Sweep Gen., 1-18 GHz $9000.00
HP 8601A Signal/Sweep Gen., 0.1-110 MHz $4000.00
HP 8620C Sweep Oscillator Frame $500.00
HP 86222B-002 RF Plug-in, 10-2400 MHz $550.00
HP 86235A RF Plug-in, 1.7-4.3 GHz $2250.00
HP 86240A RF Plug-in, 2.0-8.4 GHz $500.00
HP 86290B RF Plug-in, 2.0-18.6 GHz $1000.00
HP 8709B Synchronizer, for 8620 sweepers $2250.00
WAVETEK 1067 Sweep Gen., 1-400 MHz, 75 Ohms $250.00

BOONTON 4200A Digital Power Meter,1MHz-12.4GHz $400.00
BOONTON 42B/41-4B Power Meter, 1 MHz-12.4 GHz $900.00
BOONTON 42B/41-4E Power Meter, 1 MHz-18 GHz $475.00
BOONTON 42B/42-S/3 Power Meter, 1 MHz-8 GHz $650.00
HP 432A/478A Power Meter, 0.01-10 GHz $375.00
HP 432B/478A Digital Power Meter, 0.01-10 GHz $375.00
HP 435A/8481A Power Meter, 10 MHz-18 GHz $450.00
HP 435A/8482A Power Meter, 0.1-4200 MHz $1000.00
HP 8486A Power Sensor, 33.0-50.0 GHz $1000.00
WAVETEK 1034A Portable Power Meter, 0.001-18GHz $1500.00
RACAL 9303-opt.15 TRMS Level Meter,2 ch.,10k-2 GHz $375.00
AILTECH 7615 Noise Gen., 0.01-1.3 GHz,15dB ENR $1100.00
BOONTON 82AD FM/AM Modulation Meter $350.00
HP 11975A Levelled Amplifier, 2-8 GHz $1000.00
HP 8447E Amplifier, 0.1-1300 MHz,+12.5dBm $1200.00
PANASONIC VP-8125A FM Stereo Signal Generator $600.00

COAXIAL & WAVEGUIDE

BIRD 8087 75 OHM Load, 25W, DC-1 GHz, N(f) $850.00
DIELECTRIC C43415 Trombone Line, 0-250 deg./GHz $100.00
GORE Instrumentation Grade SMA Cables $75.00
GR 874-LK20 Variable Length Air Line, 20-44cm $200.00
GR 900-LB Precision Slotted Line $450.00
HITACHI ME1513 Precision Attenuator, 60-90 GHz $750.00
HP 11691D Dir. Coupler, 22 dB, 2-18 GHz $500.00
HP 11692D Dual Dir. Coupler, 22 dB,2-18 GHz $1000.00
HP 776D Dual Dir. Coupler, 940-1900 MHz $250.00
HP 778D-opt.011 Dual Dir. Coupler, 20 dB,0.1-2GHz $400.00
HP 779D Dir. Coupler,20 dB, 1.7-12.4 GHz $375.00
HP 908A Coaxial Termination, DC-4 GHz $50.00
HUGHES 41214H Tunable IMPATT Source, 37-39 GHz $1250.00
HUGHES 47134H-1105 52 GHz IMPATT Source, FM/AFC $1500.00
KAY 442D 75 OHM Step Atten., 0-101 dB $90.00
KRYTAR 1822S SMA Mini Dir. Detector, 2-18 GHz $175.00
MAURY 2505C Sliding Termination,0.9-18.0 GHz $275.00
MAURY 8045D Double Stub Tuner, 1.8-18 GHz $350.00
MILITARY AS-1346B Double Ridge Horn, 3-8 GHz, N(f) $75.00
NARDA 26102 Dir. Coupler, 30 dB, 2-18 GHz $150.00
NARDA 3000-SERIES Directional Couplers $150.00
NARDA 3090-SERIES Precision Hi Directivity Coupler $225.00
NARDA 372NM Sliding Termination, 2-12.4 GHz $90.00
NARDA 4000-SERIES SMA Mini Directional Couplers $75.00
NARDA 4222-16 SMA Mini Dir. Coupler, 1-18 GHz $225.00
NARDA 5070-SERIES Precision Reflectometer Couplers $300.00
NARDA 705-69 Step Atten., 0-69 dB, DC-18 GHz $550.00
TRG A526 WR28 Phase Shifter, round flange $200.00
WEINSCHEL DS109 Double Stub Tuner, 1.0-13.0 GHz $100.00
WEINSCHEL DS109-L Double Stub Tuner, 0.4-4.0 GHz $100.00
WEINSCHEL DS109-LL Double Stub Tuner, 0.2-2.0 GHz $150.00

MISCELLANEOUS

HP 1631D Logic Analyzer / DSO $1650.00
HP 5006A Signature Multimeter, HPIB $675.00
TEK 1240/D2/D2 Logic Analyzer, 36 ch., 50 MHz $1250.00
HP 28687A LAN Wire Test Instrument $750.00
HP 59401A HPIB Bus Analyzer $700.00
HP 653A Test Osc.,10 Hz-10 MHz, Video Mod $150.00
HP 83001A Microwave Repeater, 3.7-4.2 GHz $750.00
KSI/ODETICS AITG-PC IRIG-B Time Base Card for PC/AT $250.00
SCI.ATLANTA 4647 IF Noise Insertion Test Set $1250.00
TEK 1411R-opt.04 PAL Test Signal Generator $2750.00
TEK 144 NTSC Test Signal Generator $700.00
TEK 521A PAL Vectorscope $1500.00
W&G RM-40 70 MHz Radiolink Measuring Set $1750.00
HP 37204A-opt.2 2 port Fiber-Optic HPIB Extender $600.00
HP 59307A HPIB VHF Switch $200.00
HP 82937A & 39A HPIB & Serial Interfaces $50.00
P.A.R. 5206 Lock-In Amplifier, 2 Hz-200 kHz $3000.00

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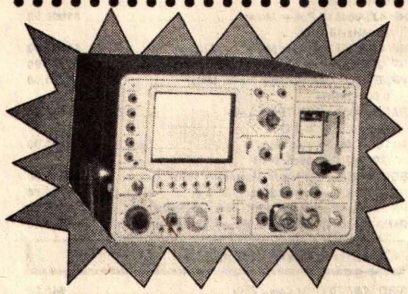
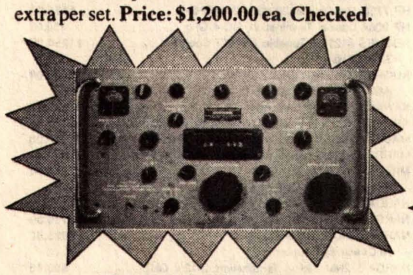


INDUSTRY STANDARD TEKTRONIX 491 SPECTRUM ANALYZER

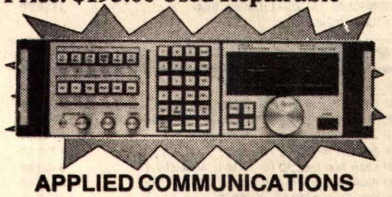
Covers 10 Mhz - 40 Ghz. Solid state portable unit features internal phase lock, minimum sensitivity is -100 dBm. A 12.4 Ghz mixer is included with each unit. External mixer kit (40 Ghz) and attenuators are available with purchase of each 491 for $400.00 extra per set. **Price: $1,200.00 ea. Checked.**



R390A RECEIVER

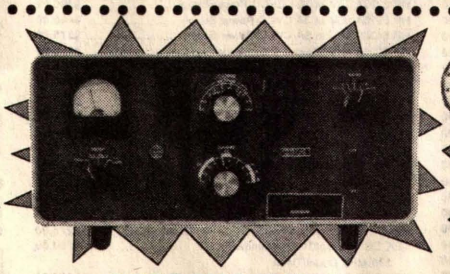
"The **CLASSIC RADIO RECEIVER** that is still a great investment". - These units are complete with ***orig. meters*** and cover the frequency range of 0.5 - 32 Mhz in AM, CW, MCW with direct frequency readout via mechanical digital display -physically complete, less covers.

Price: $195.00 Used Repairable



APPLIED COMMUNICATIONS VHF/UHF RECEIVER SR-2155

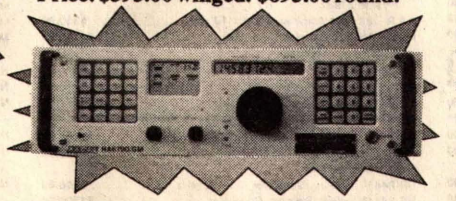
This digital high performance radio operates from 20Mhz-500Mhz. Modes of operation are AM, FM, CW, PLS, LSB, USB with bandwidths of 20, 60, 100, 300, KHz and 2 or 4 MHz. This unit contains a high performance ovenized oscillator, HPIB interface, "very hot front end", 21.4 MHz IF output and dial or direct frequency entry. **Price:$2750.00**



COLLINS 30L-1 POWER AMPLIFIER

One of the finest mid-size linear amplifiers ever produced specifically for the Premier Ham Radio Operator. It covers the 80,40,20,15 and 10 meter bands in either SSB, CW, RTTY or SSTV modes. Input drive power is 70-100 watts for full output. Power input is 1200watts, @ 115/230 vac 60 Hz. **Output power** is 650 watts RF (1000w @ reduced duty cycle).
These units are in **exceptional** condition complete with cables and connectors. If your looking for the amp opportunity of a life time, you've just checked-in!!!

Price: $595.00 winged. $695.00 round.

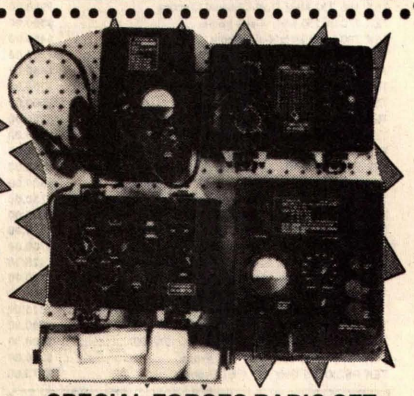


RACAL RECEIVER RA 6790/GM

Superior quality and design are standard in this 500Khz-30Mhz general coverage receiver. Modes of operation are AM,FM, CW,U/LSB,ISB -optional, with room for seven bandpass filters. The illuminated LCD display features large readable digits for frequency and mode status as well as AF or RF signal strength.Tuning can be directly entered via keypad or with a tuning knob. Three different gain modes are Manual, Automatic, and Automatic with selectable threshold. Fully Checked & Operational.
Price: $995.00 Radio only-less filters.
Bandpass Filters: 400Hz/1.2KHz/2Khz/6.8KHz 16Khz/USB/LSB are **$65.00 ea.** max 4 per unit.

All Prices in U.S. Dollars
Please include telephone/fax number with mail-in orders.
Orders must be prepaid by guaranteed instrument.

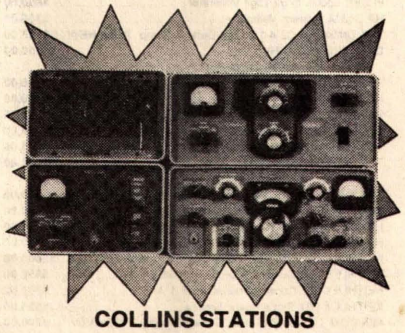
Manuals available at extra cost



SPECIAL FORCES RADIO SET R-1004/GRC-109 T-784/GRC-109

"Its a dream come true."Complete GRC-109 radio sets including all the goodies as follows:
- R-1004/GRC-109 Receiver
- T-784/GRC-109 Transmitter
- PP-2684/GRC-109 Power supply (AC,DC)
- PP-2685/GRC-109 Power supply (AC only)
- CN-590/GRC-109 Voltage regulator (For hand crank generator)
- Plus Headset, Accessory kit with new spare tubes and parts, original manual and cables.

These are new in the box. A ***FABULOUS*** collector item!! **Price : $350.00 Complete sets only.**



COLLINS STATIONS INCLUDING

KWM-2A Transceiver, 30L-1 Power amplifier, 312B-4 Station console, 516F-2 Power supply
These units are physically complete, look OK inside and on the front panel, but require a case repainting. All tubes are included with these sets.
Call for further details, these are priced to sell fast !!
Price: $900.00 for complete sets only (not functionally tested)

Flea Market Prices by Mail!!!

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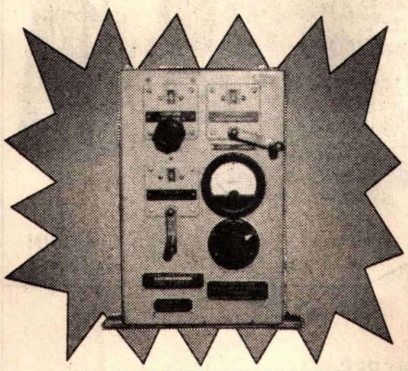
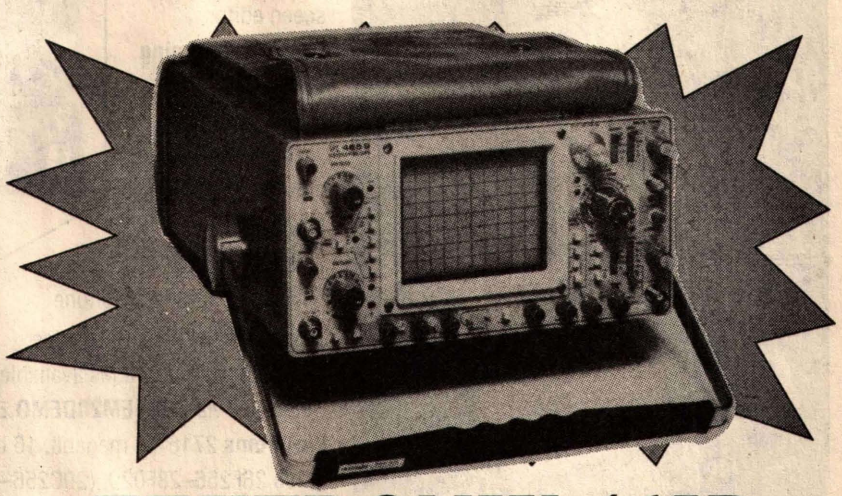


TN-339 ANTENNA TUNER

Originally designed for the famous T-368/URT AM transmitter. Frequency range is 1.5-20 MHz. Contains ceramic variable inductors and fixed capacitors for tuning elements, as well as RF ammeter. **Price: $149.00 ea.**



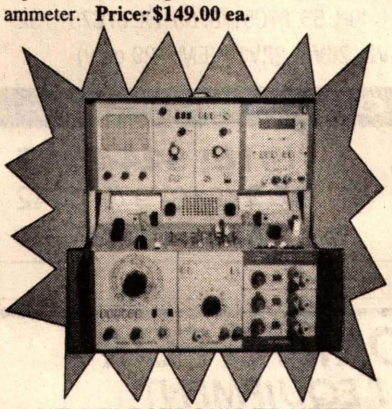
TEKTRONIX 465B

Proof is in the pudding when it comes to this instrument's track record. There's no doubt, that popularity speaks many languages when speaking of the "465B". This excellent instrument continues the tradition of the standard 465 oscilloscope by adding useful features such as CH-1, CH-2 sum or difference, trigger view in any combination, alternate sweep and trace selection versatility. Many technicians dream of owning a quality 100-MHz oscilloscope, but funding rairly permits. Fortunately, we were recently able to aquire a limited supply of 465B-s in nearly *new* condition. Our *LOW PRICES* will likely permit "you" to own one of the best scopes anywhere in the country. If your need is current and action *swift* you too will be a member of a growing club!!!

SELECTED EXCELLENT COND.....$849.00

VERY GOOD CONDITION.....$695.00

These instruments are fully checked out and calibrated. They are supplied with an original front panel cover and complete service manual. Original TEK Probes are $75.00 each with each purchase.

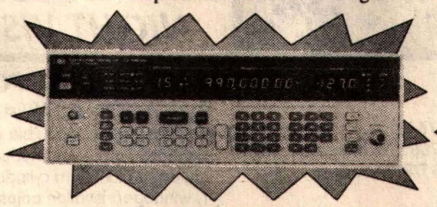


NIDA ELECTRONIC TRAINER

For those of you with limited funds this system provides you with the most essential instruments in one system. It incorporates the following:

- -10MHz oscilloscope
- -Autoranging DVM
- -Function generator
- -3 variable dc power supplys
- -1 variable ac power source
- -Precision decade resistance
- -Speaker and 2 analog meters

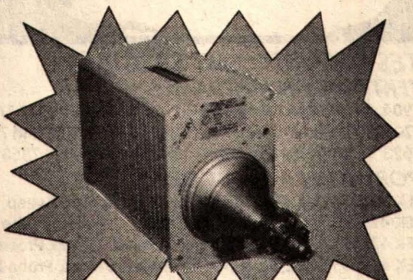
This unit comes complete with a number of electronic experiments assembled on easy to use plug-in cards. **Price: $495.00**



HEWLETT PACKARD 8656B SYNTHESIZED SIGNAL GENERATOR

This Generator operates from .1Mhz-990Mhz. Modulation is AM or FM with int 400Hz/1KHz modulation. This unit contains a high performance ovenized oscillator OPT 001, HPIB interface and OPT 002 rear panel output. High-performance and economy make this a great investment. The units are "NEW" never used still factory sealed.

Price: $6775.00 Fully Checked.



BIRD TERMILINE COAXIAL DUMMY LOAD

Recomended maximum input power is 500 watts input impedence is 50 Ohms.
Type "N" input connector for easy connection to most RF sources.

Price: $349.00 resistance checked.

Tank sight full of optics!!! **Price: $85.00**

- HP 3580A SPEC-ANALYZER 5Hz-50KHz.....$3470.00
- HP 8443A 110MHz TRACKING GENERATOR $ 900.00
- HP 8160A OPT-20 PROG PULSE GEN.....$5500.00
- HP 4260A LCR BRIDGE.....$ 385.00
- HP 3551A TRANSMISSION TEST SET.....$1275.00
- EXACT 566 SWEEP/FUNCTION GEN.....$ 345.00
- BOONTON 82AD AM/FM MOD-METER.....$1275.00
- GEN-RAD 1662 RES- LIM BRIDGE.....$ 325.00
- TEKTRONIX 1502 TDR w CHART-REC.....$3795.00
- PRC-25 TRANSCEIVER (TACTICAL).....$ 250.00
- COLLINS 651S-1 RECEIVER.....$1450.00
- R392 RECEIVER .5-30MHz.....$ 165.00
- T195 100w COMPANION XMTR TO 392.....$ 85.00
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- COLLINS 516F2 POWER SUPPLY.....$ 95.00

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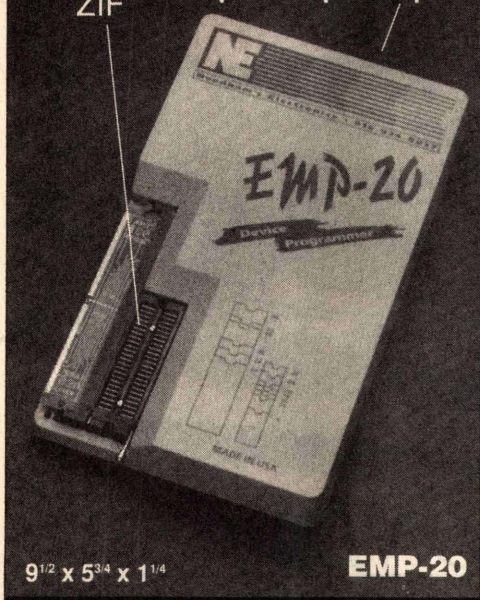
$449.95 Device Programmers $139.95



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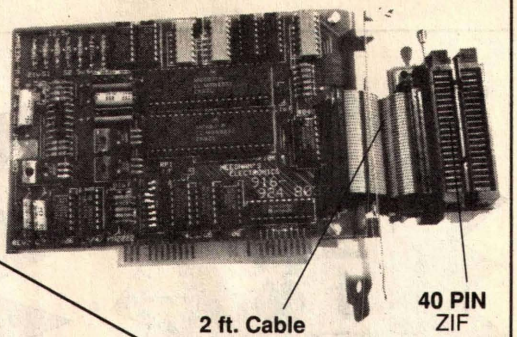
- **Flash** 28F256–28F020, (29C256–29C010 (EMP-20 only))
- **Micros** 8741A, 42A, 42AH, 48, 49, 48H, 49H, 55, 87C51, 87C51FX, 87C751,752
- **GAL, PLD** from NS, Lattice, AMD-**16V8, 20V8, 22V10** (EMP-20 only)

PB-10 Internal Card for PC



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7704, 200MHz M/F with, two 7A26 D/T vert., 7B80 and 7B85 T/B Manual.....$950
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PORTABLE PACKAGE DEALS
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TEK 485, 350MHz, Dual Trace, Delayed Sweep, Probe & Manual.....$995

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WYKO LADITE-256, Laser wavefront measurement system. A turnkey system for determining the wavefront quality and intensity distribution of laser sources. Operates from the visible to the infrared. The LADITE system provides full geometric and diffraction analysis. Complete system, LIKE NEW CONDITION. Replacement cost >$75K. LEASE/RENTAL available. $20K

LASER TRIMMING STATION, QUANTRAD 1010X Pulsed xenon laser. Perfect for trimming resistor networks. SPECS: 60 uj per pulse, TEMoo, 200W peak, 300nS pulse width, 4 to 6 PPS. 526 to 539nm. Air cooled, 115VAC powered. Includes video and direct view microscope, F.O. illuminator and manual XY table. EXCELLENT CONDITION, low hours. Two available.....$1500ea.

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WARNING: CAN CAUSE PERSONAL INJURY, HANDLE WITH CARE.
TWO MODULES..... $8.95 or 10 MODULES.....$39.95

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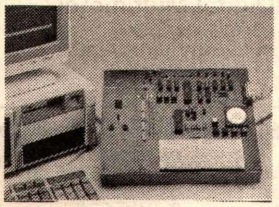
COMPUTER/MICROPROCESSOR TRAINER

Let our low-cost BGC-8088 Microprocessor trainer lead you to the advanced 80386, 80486, ...etc.. Our training systems will help you learn BASIC, C, and ASSEMBLY languages programming and microprocessor/computer system hardware design and troubleshooting



CIC-100 only $549.00

Features: Operate on IBM PCXT/AT or compatible, controlled by ASSEMBLY, C, or BASIC programming languages, 800-pin solderless breadboard for circuit design and test, I/O drivers for controlling relay, step motor, LED, speaker ..., experiment manual. Application control modules available, including step motor, matrix key-pad and traffic light, A/D, D/A, F/V, V/F converters.

BGC-8088 only $699.00

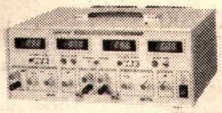
Features: Assembly language coding, assembler, disassembler, single step and multi-breakpoint program debugger, display and rewrite registers, download/upload programs from/to external systems(IBM PC or compatible), I/O drivers, 56-key large size keyboard, LCD display, RS-232, UART, printer interface, two expansion slots, +/-5V, +/-12V switching power supply, user's guide and experiment guide, Practical control applications available, such as stepping motor, matrix display,.. etc., and .. more.

Be our partner!!! Seeking regional distributors & dealers. We do OEM..
Visit us at EDS '94, booth 3522, 4/26 - 4/28, Las Vegas Hilton Hotel.

DC POWER SUPPLY

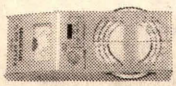
PS-303 $159.00
0-30VDC, 0-3A
0.02%+2mV line regulation
0.02%+3mV load regulation
1mVrms noise & ripple; Short circuit & overload protection.

PS-305 $239.95
0-30VDC, 0-5A.



8110 $329.95
0-60VDC, 0-3A.
8112 $449.95
0-60VDC, 0-5A.
8109 $749.95, dual output, 0-60VDC, 0-5A, independ tracking operation. Low ripple.
8202(8203) $499.95($549.95), riple output, 0-30VDC, 0-3A(5A), fixed 5VDC/3A, indepedent tracking operation, constant voltage and current.

GRID DIP METER

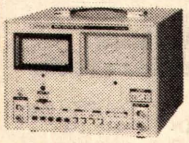


DM-4061A $89.95
1.5-250MHz, 6 bands;
6 plug-in coils, 2 transistor, and 1 diode.
MODULATION: approx. 2KHz Sinewave
CRYSTAL OSCILLATOR: 1-15MHz
POWER SUPPLY: 9VDC

AM/FM SWEEMAR SCOPE

SM-6225B/C $1999.95
FREQ RANGE:
420-490KHz(AM),
10-11.4MHz(FM).
ACCURACY: +/- 0.1%
MARKER: (AM)455KHz,+/-5KHz, +/-10KHz;
(FM)10.7MHz, +/-7.5KHz, +/-150KHz.

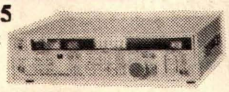
WOW-FLUTTER METER



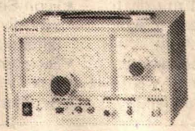
WF-3103 $699.95
FREQ. RANGE:
3KHz+/- 10% JIS/CCIR
3.15KHz+/-10% DIN.
MEASURE RANGE:
0.03/.1/.3/3% full scale.
ACCURACY: +/-5%.
WF-3105A $799.95, Digital;
FUNCTION: LIN/WOW/Flutter/WTD.
FREQ CNTR: 10Hz-9.99MHz
INDICATION: CCIR/DIN/JIS.

AM/FM STD SIGNAL GEN.

SG-4110A $1999.95
FREQ: 100KHz-110MHz
DISPLAY: 6-digit LED
RESOLUTION:
100Hz (100-34.99MHz); 1KHz (35MHz-110MHz)
ACCURACY: <+/-(5X10-E5 +/-1 count)
OUTPUT RANGE: -19dBμ, -99dBμ, 1dB step
IMPEDENCE: 50Ohm VSWR 1.2

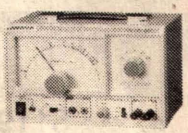


RF SIGNAL GENERATOR



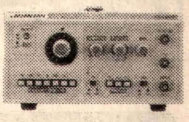
SG-4160B $119.00
100KHz-150MHz up to 450MHz on 3rd harmonics, 6 ranges, AM modulation.
RF OUTPUT: 100mVrmsto 35MHz.
MODULATION: INT. 1Khz, EXT. 50Hz-20KHz..
AUDIO OUTPUT: 1KHz, 1Vrms.
SG-4162AD $229.95, with Freq. Counter 10Hz-150MHz for internal & external source.

AUDIO GENERATOR



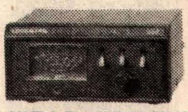
AG-2601A $119.00
10Hz-1MHz, 5ranges
OUTPUT LEVEL:
0-8Vrms sinewav
10Vp-p square
OUTPUT IMPEDENCE
600Ohm
DISTORTION: <0.05% 500Hz-50KHz
<0.5% 50KHz-500KHz
AG-2603AD $229.95, with Freq. Counter 10Hz-150MHz for internal & external source.

FUNCTION GENERATOR



FG-2100A $169.95
0.2Hz-2MHz in 7 ranges;
Sine, Square, Trianle, Pulse & Ramp
OUTPUT: 5mVp-p-20Vp-p, 1% distortion.
VCF: 0-10V control freq. to 1000:1.
FG-2102AD $229.95, generates signals same as FG-2100, 4-digit counter display, TTL & CMOS outputs, 30ppm+/-1 count accuracy.
FG-2020B $169.00
0.5Hz-500KHz, Sine, Square, Triagle.
FG-2103 $329.95, Digital sweep generator, 0.5Hz-5MHz in 7 ranges.
OPERATING MODE: sweep, AM, gated burst, VCG.
FREQ. COUNTE R: Internal.5Hz-5MHz
External 5HZ-10MHz

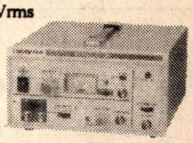
SWR/RF POWER METER



310 $89.95
FREQ RANGE:
1.8-150MHZ
RF POWER:
0-4W/20W/200W
SWR MEASUREMENT: 1.0 -◀ 4W minmum
ACCURACY: 5%-10%
INSERTION LOSS: O.3dB
INPUT/OUTPUT IMPED.: 50Ohm;SO-239 plugs.
320 $89.95, 130-520MHz.
330 $129.95, 1.8-520MHz.
SWR-3P $26.95
1.7-150MHz; RF Power: 0.5-10W, 0.5W-100W.
SWR-2P $22.95, 1.7-30MHz; RF Power: 0.5-10W.
PM-330 $149.95 1.8-500MHz; 0-5W/20W/120W

STEREO MODULATOR

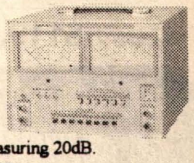
AG-2011A $549.00
RF SECTION:
CARRIER: 98MHzZ+/-2MHz
OUTPUT: 10mV, 1mV & .1mV
COMPOSITE SIGNALS:
PILOT: 19KHz+/-2KHz, 0.8Vrms
INT. MODULATION:
400KHz, 1KHz+/-1%,
1Vrms, distortion: < .5%
L-R SEPARATION: >50dB.



EXT. MODULATION:
FREQ.: 50Hz-15KHz
L-R SEPARATION: >45dB 100Hz - 3KHz
>35dB 50Hz - 15KHz.

AUTO DISTORTION METER

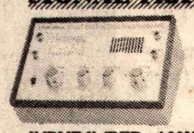
DM-3104A $799.95
MEASUREMENT:
RANGE: 0.01%-30%
0.1/0.3/1/3/10/30% full scale.
FREQ.: 400Hz+/-10%
1000Hz+/-10%(HPF).
INPUT: 3mV-100V, ratio measuring 20dB.
AUTO. SWITCHING RANGES:
Fundamental Freq. = (fo)+/-10%;
Fundamental Rejection: >-80dB at (fo)+/-5%
>-70dB at (fo)+/-10%
HARMONIC ACCURACY: +/-.5dB, 1.8(fo)-20KHz.



FREQUENCY COUNTER

FC-5250C $119.95
FREQUENCY RANGE:
10Hz-220MHz:
(HF)10Hz-20MHz,
(VHF)10MHz-200MHz
GATE TIME: 0.1 & 1sec.
INPUT SENSITIVITY: 35mV 10Hz-200MHz.
INPUT IMPED.: (HF) 1MOhm, (VHF) 50Ohm.
MAXIMUM INPUT: 10Vp-p.
FC-5260A $139.95
10Hz-600MHz.
FC-5270A $149.95
10Hz-1300MHz.
FC-5600B $329.00
10Hz-600MHz.

SIGNAL TRACER/INJECTOR



SE-6100 $134.95
TRACER:
Gain Max. 60dB
ATTENUATION:
0/20/40/60dB
INPUT IMPED.: 100KOhm
OUTPUT IMPED.: 600Ohm; SPEAKER: 8 Ohm.
INJECTOR: Freq. 1KHz Squarewave; Output Level: Continuously variable 0-4.5Vp-p.

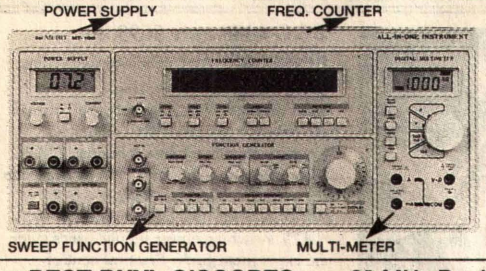
COLOR PATTERN GEN.

CPG-1366A $159.95, VHF NTSC.

CIRCLE 144 ON FREE INFORMATION CARD

Unbeatable Discount Prices

1 YEAR WARRANTY
15 DAY MONEY BACK GUARANTEE



Four Instruments in One Instrument

MT-100
Reg. $595.
$399.00

1 Function Generator
- Sine, Square, Triangle, Pulse, Skewed Sine, Ramp, TTL
- 0.02 Hz ~ 2MHz

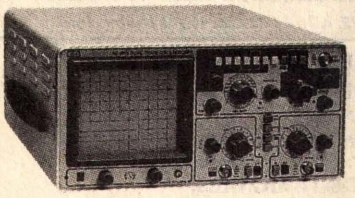
2 Frequency Counter
- 8 Digit LED
- 1 Hz ~ 100MHz
- ± (1 Hz + 1 dgt. + Time Base Error)

3 Power Supply
- 3-1/2 Digit LCD
- Triple output: #1. 0~50V, 0.5A MAX #2, 15V, 1A #3. 5V, 2A

4 Digital Multimeter
- 3-1/2 Digit LCD
- DCV, ACV, Ω, DCA, ACA
- ± (0.5% + 2 dgts)

BEST BUY! O'SCOPES

2 Yr. Parts/Labor Warranty



25 MHz Dual
Reg. $525.
$299.00

25 MHz Dual
w/Component Test
Reg. $595.
$379.00

40 MHz
Dual/Delay
Reg. $695.
$499.00

OS-3304/3324, 25 MHz

- DC to 25 MHz. Dual Channel
- 6" Rectangular CRT with Internal Graticule 10x8cm (Phillips P31)
- Uncalibration LED.
- High Sensitivity 1 mV/div to 20V/div X-Y modes, Z Axis (intensity modulation)
- Rise time 14n Sec. or less.
- Full TV Trigger for TV-V & TV-H
- Acceleration Potential 2kV

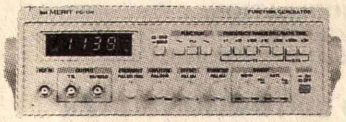
OS-3315, 40 MHz Sweep Delay

- DC to 40 MHz. Dual Channel
- Delayed Sweep 100nS to 1 Sec.
- 6" Rectangular CRT with Internal Graticule 10x8cm (Phillips P31)
- Uncalibration LED.
- High Sensitivity 1 mV/div to 20V/div X-Y modes, Z Axis (intensity modulation)
- Rise time 8.5nS or less.
- Full TV Trigger for TV-V & TV-H
- Acceleration Potential 12kV

GoldStar Oscilloscopes

OS-7020A. 20MHz Dual
Reg. $525. **$395.00**
OS-902RB. 20MHz Dual/Read Out
Reg. $795. **$595.00**
OS-9040D. 40MHz Delay
Reg. $695. **$575.00**
OS-904RD. 40MHz Dual/Read Out
Reg. $895. **$695.00**
OS-8100. 100MHz 8 Trace
Reg. $1,395. **$1,145.00**
Other Models *Call for Price*

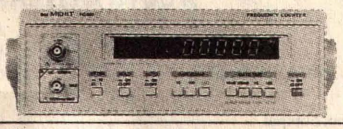
FG-150
Reg. $395. **$229.00**



2MHz Sweep / Function Generator w/Built-in Frequency Counter

- 4 Digit LED Display
- 0.2 Hz ~ 2.0 MHz
- Sine, Square, Triangle, Pulse, Skewed Sine, Ramp, TTL
- Linear or Logarithmic Sweep
- Variable DC Offset Control
- 10 MHz Frequency Counter

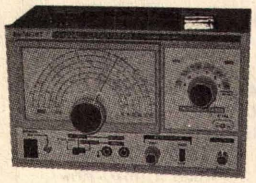
Best Buy!
1.0 GHz Counter FC-200
Reg. $395. **$199.00**



High Resolution Frequency Counter

- 1.0 Hz ~ 1.0 GHz
- 8 Digit LED Display
- Auto & Manual Range
- Measured Value Hold
- 4 Selectable Gate Times
- Below 20mV Input Sensitivity
- 1mΩ & 50Ω Input Impedance
- 10:1 Input Switchable Attenuator

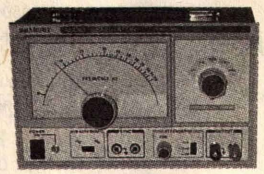
Reg. $199. **$119.00**



RF Signal Generator, SG-310 100KHz - 150MHz

- 100KHz ~ 150MHz, 6 Ranges.
- Accuracy : ± 5%
- RF Output: 100 m Vrms (Up to 35MHz Unloaded)
- Modulation
  Int. 1KHz (AM) 30%
  Ext. 50Hz ~ 20KHz
- Audio Output: 1KHz Min 2 Vrms

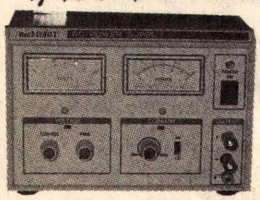
Reg. $199. **$119.00**



Audio Generator, AG-350 10Hz ~ 1MHz

- 10Hz ~ 1MHz, 5 Ranges.
- Accuracy : 5% ± 2
- Output Inpedance : 600Ω
- Sine Wave Output
  - Range : 10Hz ~ 1MHz
  - Output Voltage : 8 Vrms
- Square Wave Output
  - Range : 10HZ ~ 100KHz
  - Output Voltage : 15Vp-p

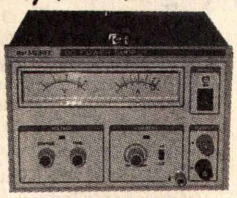
Reg. $249. **$159.00**



DC Power Supply, PS-500 0-30VDC, 0-3A

- 0 ~ 30VDC Continuously Variable
  - Regulation : ≦ 0.01% + 3mV
  - Ripple Voltage : p-p ≦ 2m Vrms; ≦ 1mV
- 0.1A ~ 3A Constant Current
  - Regulation : ≦ 0.2% + 3mA
  - Ripple Current : ≦ 3m Arms
- Short Circuit Overload Protection w/Indicating Lamp

Reg. $399. **$289.00**



DC Power Supply, PS-540 0-16VDC, 0-10A

- 0 ~ 16VDC Continuously Variable
  - Regulation : ≦ 0.01% + 3mV
  - Ripple Voltage : p-p ≦ 2m Vrms; ≦ 1mV
- 0.1A ~ 10A Constant Current
  - Regulation : ≦ 0.2% + 3mA
  - Ripple Current : ≦ 3m Arms
- Short Circuit Overload Protection w/Indicating Lamp

Oscilloscope Probes Switch Selectable X1 / X10

HP-9060, 60MHz
Reg. $29. **$15.00**

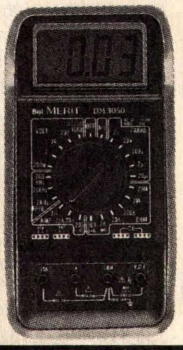
HP-9150, 150MHz
Reg. $49. **$22.00**

HP-9250, 250MHz
Reg. $59. **$29.00**

Auto Bargraph w/Holster

DM3200
Reg. $99.
$59.00

- Auto & Manual
- 3-1/2 Digit
- 32 Seg. Bargraph
- Diode Test
- Continuity Beeper
- Data Hold
- Auto Power Off
- Low Battery Mark
- Over Range Mark
- Holster



Multimeter Multi-Function w/Holster

DM3000
Reg. $69.
$44.00

DM3050
Reg. $99.
$54.00

DM3100
Reg. $99.
$54.00

- 3-1/2 Digit
- 1.5" Big LCD
- Heavy Duty, 20A
- Capacitance
- TR-hFE
- Diode
- Low Battery Mark
- Over Range Mark
- Protective Holster
- Tilt Stand

DM3050 Only
- Frequency
- Continuity Beeper

DM3100 Only
- Temperature w/ Optional Probe
  Reg. $15 **$8.00**
- Continuity Beeper

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CIRCLE 288 ON FREE INFORMATION CARD

ARE YOU BEING "BUGGED?"

EVEN AS YOU READ THIS, countless individuals and firms are being enormously damaged by having their private conversations overheard, monitored, and\or recorded.

Almost without exception and AFTER the fact, the victims make a statement something along the lines of "But, I never thought it would happen to ME!"

OUR FINEST Counter-Surveillance Device

THE ULTIMATE IN "BUG" DETECTION EQUIPMENT "DEBUGS" ROOMS AND TELEPHONES!

If you require GUARANTEED PROTECTION against electronic telephone monitoring devices and also require COMPLETE CONFIDENTIAL PRIVACY in certain rooms and areas, we highly recommend the COUNTER-SURVEILLANCE DETECTOR CSD-18.

CONDUCT A PROFESSIONAL SEARCH... ANYTIME...ANYWHERE!

Every newspaper and magazine article and every radio and TV story discussing some new episode involving "Bugging" devices, continues to increase the ever growing demand for electronic Counter-Surveillance "sweeps" and equipment. The very limited supply of competently trained and equipped Counter-Surveillance specialists has created a situation where "sweep" rates exceeding $250 per hour are now considered reasonable and appropriate.

This is an exciting, immensely interesting and profitable field that you can enter with a minimum investment. Two hours actual practice with the CSD-18 will have you "reading" and "clearing" telephones and rooms with professional ease and competence. The average fee for "debugging" a single telephone is over $200.00. It requires about 45 minutes to complete the job and once it gets around that YOU can provide this service, you'll quickly have more clients than you can handle. Even if you choose to provide "sweeps" for only a small number of friends and associates, your initial investment will quickly be returned many times over.

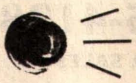
EXTREME SENSITIVITY!

This is our finest piece of detection equipment! The CSD-18 quickly locates electronic eavesdropping devices in telephones, homes, offices, vehicles, boats, or concealed on the body. It will actually pick up many eavesdropping transmitters at ranges exceeding 25 feet! Extreme sensitivity is obtained via ultra-efficent amplification circuitry following the RF detection stages. Excellent quality Dynamic Headphones exclude all external sounds to further enhance detector output.

The presence of any "bug" is immediately indicated via a pronounced meter deflection. The CSD-18 quickly "homes-in" on eavesdropping transmitters and immediately pinpoints their location. The closer you get to the "bug", the further the needle moves to the right. It's as simple as that.

FULL RANGE DYNAMIC HEADPHONES

"FLASHING" LED WARNS YOU INSTANTLY!



And, for maximum telephone security, the CSD-18 automatically analyzes a sophisticated series of electronic measurements along the telephone line and converts the analysis into an easy to follow, step by step, test procedure. No technical knowledge is required or necessary. A visual indication (via a flashing LED) immediately reveals the presence of the various types of telephone "taps" and the flashing sequence identifies the actual type of eavesdropping device.

MAXIMUM SECURITY — EASY OPERATION!

Latest Computer-Age IC circuitry designed exclusively for maximum security and ease of operation, assures the utmost privacy protection possible today against virtually all types of room "bugs" and telephone "taps". The CSD-18 detects even the very latest ultra-sophisticated devices specifically designed to defeat detection via polarity negating circuitry. Also includes multi-line option for testing business telephones.

FREE BONUS!

FASCINATING HI-TECH INFORMATION PACKAGE INCLUDED FREE!

LATEST EAVESDROPPING DEVELOPMENTS

A detailed analysis of a variety of extremely fascinating hi-tech devices and procedures used for ultra-sophisticated audio and video eavesdropping including infrared monitoring, multi-data eavesdropping and interception, miniature micro-wave devices, new methods for listening thru walls, etc., with many schematics included. You'll learn about electronic voice changers, corporate spying, how data banks are accessed to research anyone and anything, eavesdropping by neighbors; space age personnel and vehicle tracking systems, how missing persons are found, how lie detectors are deceived, and a fact-filled section on Eavesdropping Law.

BIG MONEY IN COUNTER-SURVEILLANCE

Complete information describing the fantastic opportunities that are now open to trained Counter-Surveillance technicians and exactly how a number of individuals and firms are reaping a huge bonanza in the booming "Debugging" business! You'll learn how the ever increasing use of Electronic Listening Devices by investigative agencies, government agencies, unscrupulous business competitors, jealous suitors, etc., has created a tremendous demand for this type of service.

A comprehensive information package JAM-PACKED FULL of some of the most exciting and fascinating reading imaginable. Reads like a James Bond novel, with one important exception...IT'S NOT FICTION!

THE ONE "BUG" TO FEAR MOST!

While most individuals are now somewhat guarded in their telephone conversations, they still rather naively feel secure in the "privacy" of their own home or office. However, the most common type of tap presently used by eavesdroppers picks up ALL SOUNDS AND CONVERSATION WITHIN A ROOM....**WITH THE TELEPHONE STILL ON THE HOOK!**

Due to this devestating capability, this "Infinity" tap (variously referred to as Infinity Transmitter, Hookswitch Bypass, 3rd Wire, Harmonica Bug, etc.), has become the "bug of choice".

In flagrant violation of federal law prohibiting their use and sale, these devices in various forms are openly advertised in many technical publications for as little as $75. Literally thousands of these devices are now in the hands of unscrupulous individuals all over the country!

In response to this ever-growing threat, a uniquely engineered feature of the CSD-18 now also detects Infinity type devices anywhere "down the line".

In other words, if anyone ... ANYWHERE ... is utilizing the telephone tip and/or ring wires to monitor your private room conversations while your telephone is on the hook, you'll immediately be made aware of it via a flashing LED!

100% POSITIVE INDICATION

The CSD-18 also flawlessly detects "Series" and "Parallel" telephone transmitters and "Telephone Recording Devices". And, a separate feature silently indicates when extension phones are picked up or being used. The CSD-18 completely eliminates all doubt and guesswork.

EXCLUSIVE "LISTEN-IN" FEATURE!

The CSD-18 will even allow you to "listen-in" to exactly what the eavesdropper is monitoring. And, without the eavesdropper ever becoming aware that he has been detected! We are unaware of ANY other detection equipment having this combined capability AT ANY PRICE!

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The CSD-18 provides maximum protection against ALL major catagories of surveillance equipment including:

ALL TYPES OF "CONCEALED TRANSMITTERS"
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"BODY" TRANSMITTERS
"TELEPHONE RECORDING DEVICES"
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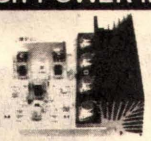
120-250W MOSFET POWER MONO AMPLIFIER AF-2 (6 lbs.) ▲▲

Power Output: 250W into 4 ohms RMS(42VX2 6A transformer is used). 120W into 4 ohms RMS(33VX2 4A transformer is used). Frequency Response: 3Hz-22,000Hz. THD: <0.03%. Signal to Noise Ratio: 91dB. Sensitivity: 1V RMS at 47k. Load Impedance: 4 or 8 ohms. Power Requirement: ±46VDC 4A or ±60VDC 6A. May use Mark V model 012 Transformer. Suggested Capacitor 10,000uf 100V Model 019. Suggested Metal Cabinet LG-1925.

Kit: $ 89.80 Asmb.$ 114.80

300W HIGH POWER MONO AMPLIFIER TA-3600 (5 lbs.) ▲▲▲



Power Output: 300W into 8 ohms RMS. 540W music power into 8 ohms. Frequency Response: 10Hz-20KHz. THD: < 0.05%. Sensitivity: 1V RMS at 47K. Power Requirement: 60 to 75 VDC at 8A. May use Mark V Model 007 or 009 Transformer. Suggested Capacitor: 10,000uf80-100V Model 019 Capacitor. Suggested Metal Cabinet LG-1925.

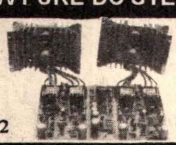
Kit 85.00
Asmb.$ 110.00

120W + 120W PRE & MAIN STEREO AMPLIFIER TA-800MK2 (4 lbs.) ▲▲

Power Output: 120W into 4 ohms RMS. 72W into 8 ohms RMS. Frequency Response: 10 - 20 KHZ. THD: < 0.01%. Tone Control: Bass ±12dB, Mid ±8dB, Treble ±8dB. Sensitivity: Phono Input, 3mV into 47K. Line, 0.3V into 47K. Signal to Noise Ratio: 86dB. Power Requirement: 40V DC @ 6A. May use Mark V Model 001 or 008 Transformer. Suggested Metal Cabinet Model LG-1924.

Kit: $ 63.92 Asmb.$ 73.95

80W + 80W PURE DC STEREO MAIN POWER AMPLIFIER TA-802 (4 lbs.) ▲▲



Power Output: 80W per channel into 8 ohms. THD: < 0.05%. Frequency Response: DC to 200 KHZ, -0 dB, -3dB @ 1W. Power Requirement: 30V AC X 2 @ 6A. May use Mark V Model 001 or 008 Transformer. Suggested Capacitor 8,200uf 50V Model 017. Suggested Metal Cabinet LG-1924

Kit: $ 45.94
Asmb.$ 59.72

30W + 30W PRE & MAIN STEREO AMPLIFIER TA-323A (1 lb.) ▲

Power Output: 30W into 8 ohms RMS per channel. THD: < 0.1% from 100 HZ to 10 KHZ. Sensitivity: Phono 3mV @ 47K. Tuner, Tape 130mV @47K. Signal to Noise ratio: 80dB. Power Requirement: 22 to 36V AC, 3A. May use Mark V Model 002 Transformer. Suggested Cabinet LG-1684.

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LG-1983	2¼X19X8"	(7 lbs.)	32.50

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It has inputs for VCR, LD, CD and can also be used with tuners, tape decks and LP discs. Frequency Response: 20 Hz-20KHz. THD:Front Channel 0.05% Rear Channel <0.25%. Input signal voltage: 0.1-3.5V. Output: Front Channel 0.1-3.5V Rear Channel 6.6V. Delay Time: 5-50 ms. Input Impedance: 47K Power Requirement: 100-120VAC, 60Hz. Ready to plug when assembled. Asmb:$85.00

Kit:$73.00

AC/DC STEREO PRE & MAIN AMP.

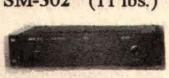
SM-720 ▲▲ (7 lbs.)

120WX2 Music Power THD: <0.2%. Input Sensitivity: Tape 300mV 47K, CD/Aux 300mV 47K, Phono 3mV 47K, Guitar/Mic 3mV (600 ohm - 47k ohm). Tone Control: Treble±8dB, Bass±8dB. Frequency Response: 20Hz-20KHz. Signal to Noise Ratio: 78dB. Power Requirement: AC 110/60Hz DC 12-16V. Ready to plug in when assembled. Asmb:$ 89.00

Kit:$ 75.00

60+60W STEREO POWER AMP.▲▲

SM-302 (11 lbs.)



It provides 3 input jack pairs. One pair accept a high impedance microphone. The two remaining pairs are for high & low level input sources. Power Output: 60W per channel into 4 ohms RMS. 20Hz-20KHz. THD:<0.1%. Input Sensitivity :Mic /Guitar 10mV, Hi 380mV, Lo 640mV.Ready to plug in when assembled. Asmb.:$ 85.00

Kit:$ 73.00

3½ MULTI-FUNCTION LED DPM ▲▲

SM-43 (1 lb.)

AC/DC Voltage range: 1mV-1000V. Thermometer range :0-100C. DC current range: 1 microamp - 2 amp. Capacitance range: 1pf to 2 microfarads. Frequency Counter: 10HZ-20KHZ. Max indication ±1999. Power Supply: 5-6V DC, 200ma. Asmb:$ 43.00

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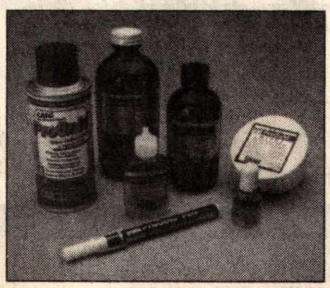

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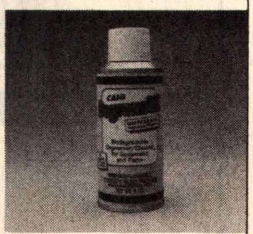

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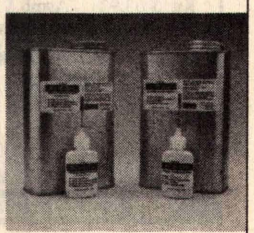

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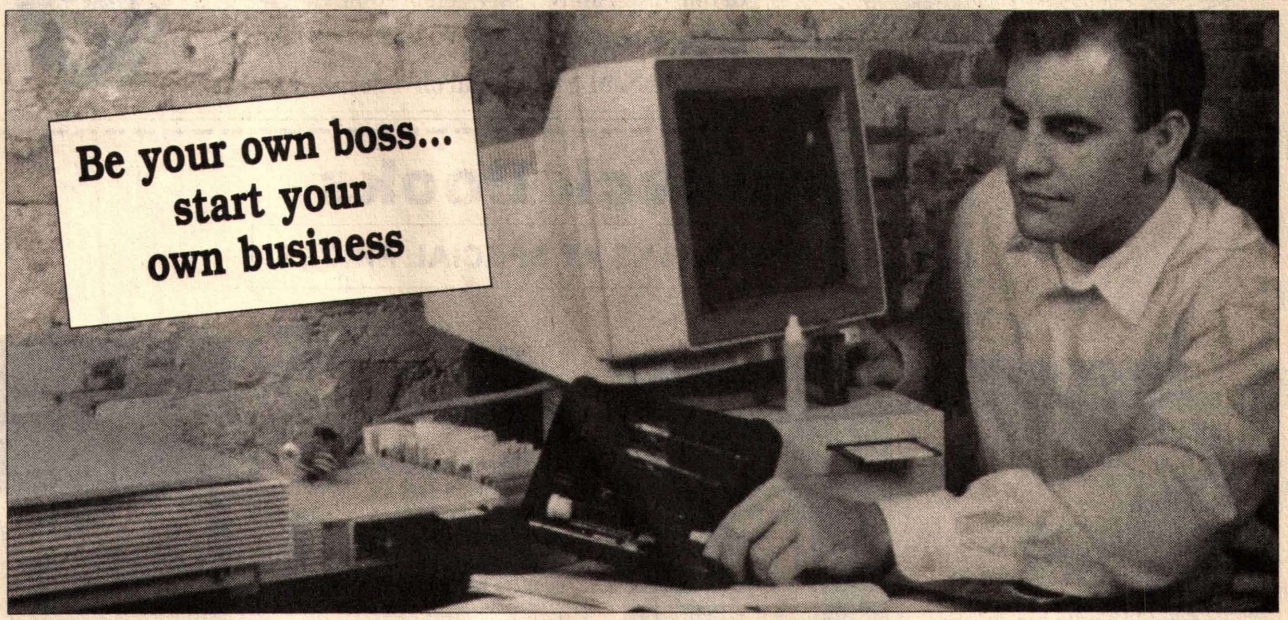

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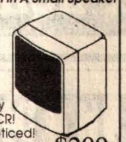

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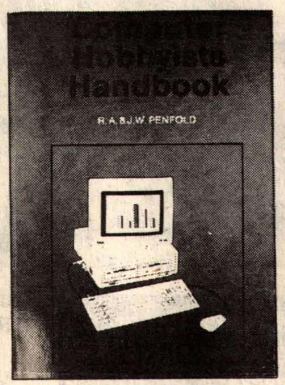

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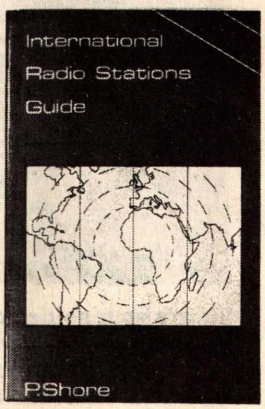

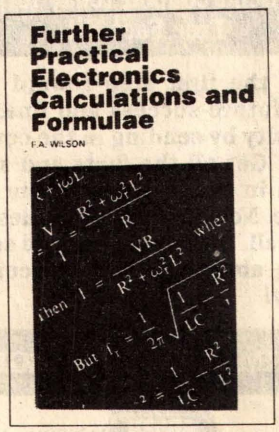

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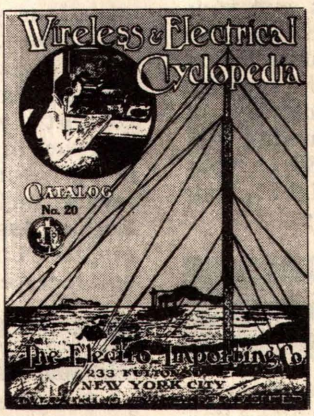

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PC-BASED OSCILLOSCOPES OUTPERFORM STAND-ALONES IN COST AND PERFORMANCE

CHASE SCIENTIFIC INTRODUCES 2 NEW SCOPES FOR 1994

By Staff Writer

Chase Scientific Company has just introduced its new 4-Channel 60 MHz and 100 MHz PC-Based Digital Storage Scopes. These scopes compliment its already existing line of 2-channel scopes which have useful bandwidths of 20, 40, 60, and 100 MHz. Each ChaseScope™ System is completely self-contained on a single midsize add-on board (2 required for 4 channel version), at prices that will make the competition cry. Just plug in the board(s), attach your scope probes, load the ***free software*** and you're on your way.

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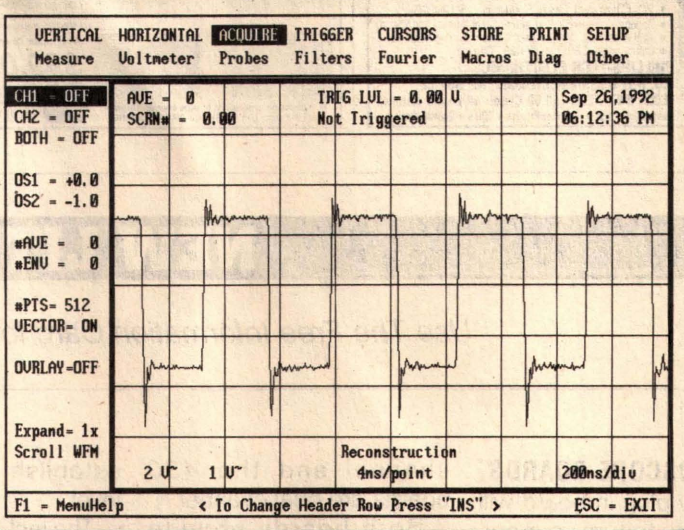

COMPARISON CHART OF PC-OSCILLOSCOPES

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Maximimum Time Resolution	1ns	1ns	4 ns	4ns	1ns	1ns
Vertical Resolution	8-bit	8-bit	8-bit	8-bit	8-bit	8-bit
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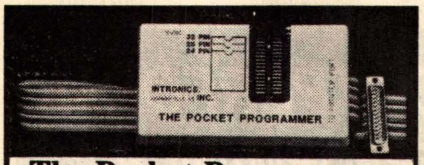

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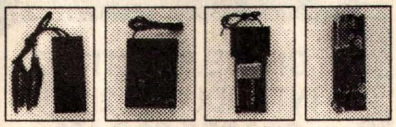

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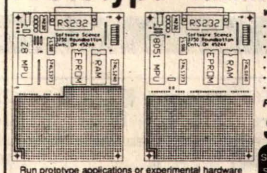

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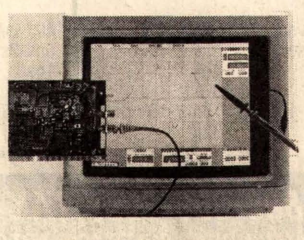

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The included *BenchCom software* provides the user with the ability to see and print waveforms, translate the waveform data file to an ASCII list or spreadsheet format, and control the oscilloscope card from DOS and Windows.

Optional *BenchTop* software provides a "point-and-click" graphics user interface with the ability to store and recall waveforms and test setups and change settings without the need for the user to learn the commands.

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LED Transluminators: Multi-Chip Edge, Post and Back-Lighting Illuminator Modules (No. 87-2). Lumex Opto/Components Inc., 292 East Hellen Road, Palantine, IL 60067; Phone: 708-359-2790; Fax: 800-944-2790; free.

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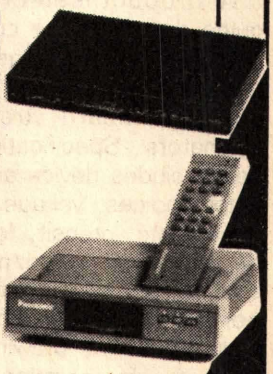

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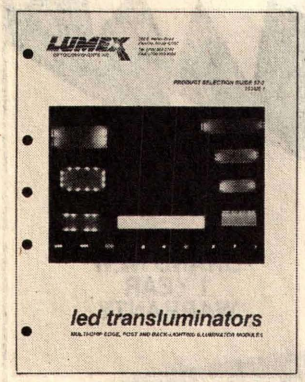

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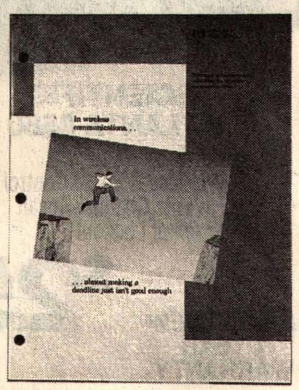
from Lumex provides technical information on its new line of illumination products that it calls transluminators. They are substrates with multiple green, amber and red LED dies for back and edge lighting.

Lumex says that the LED displays can backlight liquid-crystal displays, illuminate overlay graphics and edge-light instruments, and enhance color graphics. Viewers can see displays or graphics in low ambient light with the aid of the multiple LED chips on a board.

A product selection guide describes the complete line of 18 edge-lit transluminators and 12 "chips-on-board" transluminators. Specifications data includes device area, color choices, voltage requirements, intensity (candelas —mcd or cd/m^2), and number of LED chips per device. The brochure includes outline drawings, limits of safe operation, information on reflectors, light sources, and substrates, as well as options in reflective coating, adhesives, overlays, and device encapsulants.

Test and Measurement Solutions for Wireless Communications. Hewlett-Packard Company, 3000 Hanover STreet, Palo Alto, CA 94304; PHone: 800-452-4844; free.

This 18-page, full-color brochure from Hewlett-Packard Company is intended to help communications managers and engineers select appropriate HP test equipment products for research and development, manufacturing, and field testing of many kinds of wireless telecommunications equipment.



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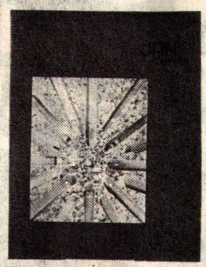
The more than 30 products covered include spectrum analyzers, channel simulators, network analyzers, mobile test software, signal generators, cell-site test sets, and audio analyzers. A two-page table lists the communications systems that can be tested, and the kinds of measurements that can be made with each of the instruments described.

Quartz-Crystal Design Guide and Catalog. Jan Crystals, Design Engineering Department, 2341 Crystal Drive, P. O. Box 60018, Fort Myers, FL 33906-6017; Phone: 800-JAN-XTAL; Fax: 813-936-3750; free.



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This 12-page catalog describes Jan Crystal's frequency-control crystals. The catalog includes descriptions of low-frequency, custom, and microprocessor crystals, as well as hybrid clock oscillators. Specifications and circuit drawings are given for each product. In addition, the catalog contains charts, graphs, formulas, and technical information, including a tutorial discussion of crystal frequency control.

LED Product Design Guide 84-1. Lumex Opto/Components Inc., 292 East Hellen Road, Palatine, IL 60067; Phone: 708-359-2790; Fax: 1-800-944-2790; free.

This 60-page guide contains complete descriptions, specifications, and outline dimensions of more than 2500 light-emitting diodes and assemblies made from LEDs. More than 100 new items are described including surface-mount LED products, LED arrays, LED light bars, and transluminators.

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Included are 13 pages of technical tutorial covering the theory of light-emitting diodes and other solid-state emitters and applications notes of value to the circuit designer.

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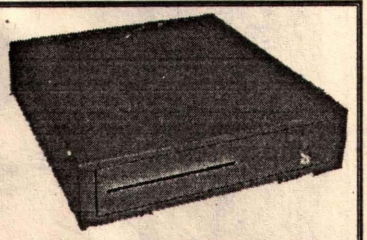

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60/40	.031	331	40
Sn63	.031	282	66

CA Residents please add 7.75% Sales tax. • Minimum shipping & handling charges $5.00. (This covers most orders) • Warranty: Used/Refurbished products have a 90 day warranty • ALL Returns must have an RMA #, call before shipping back to us. • No Returns without an invoice. Shipping & Handling charges are non-refundable • 20% Restocking charge, applies to products purchased in error & incompatibility problems. • School & University Purchase Orders accepted, others on AOC only. • Prices and availability subject to change at anytime without any notification whatsoever. • Some Products are refurbished product.

CIRCLE 282 ON FREE INFORMATION CARD

IT'S TIME TO STOP THE BURNING.

96,000 acres of irreplaceable rain forest are burned every day.

The rain forest is the world's great pharmaceutical storehouse. It provides sources for a quarter of today's drugs and medicines and seventy percent of the plants found to have anti-cancer properties.

This senseless destruction must stop. NOW!

The National Arbor Day Foundation, the world's largest tree-planting environmental organization, has launched Rain Forest Rescue. By joining with the Foundation you will help establish natural rain forest barriers to stop further burning and support on-site conservation plans to protect threatened forests.

Each and every second, a rain forest the size of a football field goes up in smoke. You'd better call now.

Rain Forest Rescue™

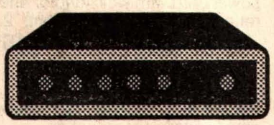
The National Arbor Day Foundation™

Call Rain Forest Rescue.
1-800-255-5500

CABLE TV
UNIVERSAL DESCRAMBLER

Combined Unit

Free Catalog CALL



PRODUCT GUARANTEE

Limited Quantity Available

1-800-664-6999

MasterCard VISA COD

UNIVERSAL 1001
Fully assembled and tested.

$169.95

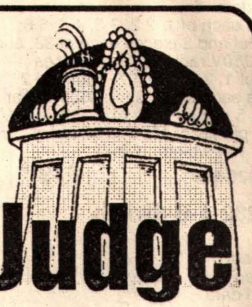
UNIVERSAL 2010
Complete Kit. Ready For the Hobbyist.

$69.95

NO FLORIDA SALES!
Product for AUTHORIZED use only. See our catalog for details.

THE HALCYON GROUP

YOU! Be the Judge



of our

6805, 68HC05 & 68HC11 Microcontroller Development Tools

Our development tools provide the fastest, easiest and most cost effective means of developing products based on the Motorola 6805, 68HC05 and 68HC11 microcontrollers. During the past eight plus years, hundreds of the worlds largest corporations, major universities and most successful companies have found this to be true. Now, if you are starting a project based on one of these microcontrollers, you can judge for yourself. Call today for a free catalog. We'll be happy to answer your questions and assist you in any way we can.

Partial Product Listing

6805 Primer includes PC Based Cross Assembler and Simulator	$269
6805/68HC05/68HC11 Cross Assemblers	from $99
6805/68HC05 PC Based Simulator/Debuggers	$99
68705 P3, P5, U3, U5, R3, R5 Programmer	$329
68HC705/68HC805 Programmer	from $395
68HC705K1 4 Site Gang Programmer	$495
68HC05 Real-Time In-Circuit Emulators	from $895
68HC11 Real-Time In-Circuit Emulators	$995
68HCx11A1/A8/D3/E2/E9 PC Based Programmer	$349

TEC *The Engineers Collaborative Inc.*
RR #3, Box 8C, Barton, VT 05822, USA

TEL: 802-525-3458 **FAX: 802-525-3451**

CIRCLE 274 ON FREE INFORMATION CARD

24 VDC BATTERY CHARGER

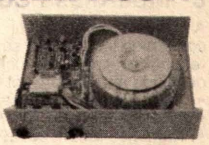
Charger's output adjusts from 24 to 30 VDC; max-charge current approx 8 amps. Uses SCR and volt sensing circuits to vary pulse duration that controls average charge current. 120 VAC 60 Hz input. Has 6 ft. line cord and 5 ft. output cable with two battery clamps. 2.5x8.8x5.8, 7 lbs sh.

#BC-24V5, NEW **$45**

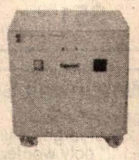
TORROID TRANSFORMER ASSY.

Assembly from above charger has 2.3"H x 4.4" dia torroid transformer with dual 24 VCT 8 amp windings, pulse charge PC board, and lower half of case. LESS cables and cover! Re-do to make charger or as basis for power supply! 6 lbs sh.

#BC-24V-ASSY **$24**



500 WATT UPS



Uninterruptable power supply (UPS) produces 120 VAC 60 Hz 500 watt output from 48 VDC input. Internal 8 cell x 6 VDC rechargeable gel-cel battery pack supplies power when normal power input is interrupted. Inverter output is modified square-wave with zero crossing. No further data; batteries functional, but no warranty as to cell life. W/casters; 14.5x12.5x10.3, 100 lbs sh.

#UPS-48-500, USED with output **$149.50**
INVERTER SECTION only from above; **#INV-48-500** **$99.50**

12.6 VDC to 120 VAC 60 Hz 500 WATT INVERTER, w/output terminal strip; 3.6x9.1x13.5, 17 lbs sh. **#RC-INV-12500, NEW** **$149.50**

ENERGY STORAGE CAPACITORS

Removed from equipment; both 10X4.5X3.5, 10 lbs sh.
88 MF 1200 VDC ..... **$17.50** **224 MF 1500 VDC** **$27**

650 AMP RECTIFIER

Motorola MR1265FL rectifier rated 300 PIV 650 amp; with hardware; 3.3x2.3x3.3, 3 lbs sh. **NEW** **$14.95**

Prices F.O.B. Lima, O. • VISA, MASTERCARD Accepted.
Allow for Shipping • Write for latest Catalog
Address Dept. ES • Phone 419/227-6573 • Fax 419/227-1313

FAIR RADIO SALES
1016 E. EUREKA • Box 1105 • LIMA, OHIO • 45802

Parts Express International Inc.

Grill Guides

Ball and socket type grill guides for attaching speaker grill to cabinet. To use, simply drill the appropriate size holes in cabinet and grill frame. 12 pair per package.

#EN-260-367 $1.80 PER PKG

Triplett Model 2202

Large, easy to read 3-1/2 digit LCD display. Tests voltage in 5 ranges to 750 VAC, resistance in 6 ranges to 20M plus diode test with audible continuity, 6 current ranges to 10A. Built-in battery test and HFE test for NPN and PNP transistors. Test leads, instructions and carrying case included. One year manufacturer warranty. Net weight: 1 lb.

#EN-390-140 $47.00 EACH

One Farad Car Stereo Capacitor

Most car amplifiers' power supplies simply lack the capability to produce large amounts of instantaneous power. By adding the 1 Farad Car Stereo Capacitor to your system it will greatly augment the power supply of your amp and help it produce incredible bass punch and dramatically improved transient response. Includes installation instructions. Specifications: 1,000,000 uf. 16VDC at 85 degrees C. Net weight: 2 lbs. 1 year guarantee. Dimensions: 8-1/2" (H) x 3" (dia.).

#EN-029-1000 $79.90 EACH

Contact Clean Plus

Contact Clean Plus is a CFC free industrial grade solvent designed to clean and lubricate all types of switches, electrical controls, and tuners. The heavy duty solvents quickly clean dirt, grease, and oxidation while leaving a fine lubricating film. Contact Clean Plus is non-flammable, safe on most plastics and can be applied on operating equipment. HCFC bond. 16 oz. aerosol.

#EN-341-035 $10.80 (1-11) $9.50 (12-UP)

8" Fiberglass Cone Bass/Midrange

A premium quality driver. The woven fiberglass cone, high loss rubber surround and 29 Hz resonance, combine to offer excellent sonic definition and deep, tight bass.

- Power handling: 70 watts RMS/100 watts max
- Voice coil diameter: 1-1/2 inches
- Impedance: 8 ohms
- Frequency response: 29-4000
- Magnet weight: 20 ozs.
- Fs: 29 Hz
- SPL: 89 dB 1W/1m
- Vas: 2.98 cu. ft.
- Qts: .39
- Qes: .47
- Qms: 2.2
- Xmax: .17 inches
- Net weight: 5 lbs.
- Dimensions: A: 8-3/8", B: 7-1/4", C: 3-13/16", D: 3-7/8", E: 1 3/8".

#EN-296-095 $55.80 (1-3) $51.50 (4-UP)

Polydax 1" Soft Dome Tweeter

1" textile diaphragm features a catenary profile for maximum stiffness. Ferro fluid cooling ensures high power handling capability with smooth and transparent sound reproduction.

- Power handling: 70 watts RMS/100 watts max.
- Voice coil diameter: 1 inch
- Impedance: 8 ohms
- Frequency response: 4000-20,000 Hz
- Magnet weight: 8-1/2 ozs.
- Fs: 1200 Hz
- SPL: 92 1W/1m
- Net weight: 1 lb.
- Manufacturer model number: TWO25M1
- Dimensions: A: 3-7/8", B: 2-7/8", C: 1", D: 2-3/4", E: 3/4".

#EN-270-046 $21.95 (1-9) $19.50 (10-UP)

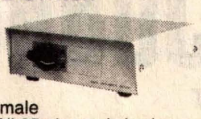
High Voltage Cap Kit

This 85 piece kit contains a selection of 250, 350, and 450 volt electrolytic capacitors. 5 pieces each of 1, 2.2, 3.3, 4.7, 6.8, 10, 22uf and 2 pieces each of 33, and 47uf, 250V radial caps. 5 pieces each of 1, 2.2, 3.3, 4.7, 10uf and 2 pieces each of 22, 33uf, 350V radial caps. 5 pieces each of 1, 2.2, 4.7uf and 2 pieces of 10uf, 450V radial caps. Net weight: 1 lb.

#EN-020-950 $49.95 EACH

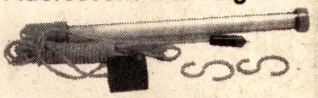
RS-232 A-B Switch

Fully shielded, steel enclosed data switch with gold plated female connectors. All 25 pins switched through. Can be used to switch multiple printers or computers. 1 year guarantee. Net weight: 1-3/4 lbs.



#EN-130-010 $10.50 (1-2) $9.95 (3-UP)

Fluorescent Work Light



Extra bright 15 watt tube that operates on 120 VAC or 12 VDC. 15 foot power cord with wall adaptor and cigarette lighter plug. Net weight: 2 lbs.

#EN-360-490 $16.90 EACH

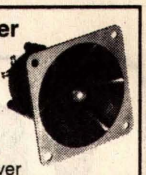
12 VDC Cooling Fans

Perfect for cooling car audio power amps. Standard mounting configuration for replacement. Manufacturer may vary.

Part #	Description	Price (1-9)	Price (10-UP)
EN-250-102	micro fan 1" x 2-3/8" x 2-3/8"	$8.50	$7.95
EN-250-160	mini fan 1" x 3-5/8" x 3-5/8"	9.90	8.90
EN-259-120	standard fan 1-1/2" x 4-5/8" x 4-5/8"	9.90	8.90

Motorola Super Horn Tweeter

Very popular super horn tweeter found in many systems. Piezo elements do not require crossover networks and impedance increases as the input decreases. Excellent power handling capability.



- Power handling: 50 watts RMS/75 watts max.
- Frequency response: 4000-27000 Hz
- SPL: 94 dB 1W1/1m
- Net weight: 2 ozs.
- Manufacturer model number: KSN1005
- Dimensions: A: 3-3/8" x 3-3/8", B: 3" C: 2-5/8", D: 1-3/4", E: 1".

#EN-270-010 $4.95 (1-9) $3.95 (10-UP)

Fuji Alkaline AA

Premium quality super alkaline batteries from Fuji feature a 100 percent mercury free formula. Long life design retains up to 85 percent of its life after 5 years in storage. Sold in packages of four.

#EN-140-155 $2.30 (1-9) $2.05 (10-UP)

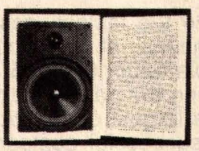
Home VCR Repair Illustrated

This illustrated guide can show you how to correct the most common VCR malfunctions without expensive tools or test equipment. Written by Richard C. Wilkins and Cheryl A. Hubbard. 400 pages in paperback. Copyright: 1991.

#EN-500-165 $19.95 EACH

6-1/2" Two-Way inwall System

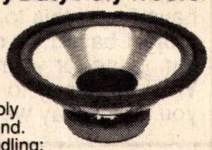
This is our most popular in-wall. Easily installed in any 2 x 4 or larger wall. Specifications: 6-1/2" poly woofer with a 10 oz. magnet, 1" field replaceable soft dome tweeter. Integral 2-way crossover with pushbutton wire terminal. 8 ohm impedance, frequency response: 40-20,000 Hz. 40 watts RMS/80 watts max power handling capability. Sensitivity: 90 dB 1W/1m. Dimensions: 8-1/2" (W) x 12" (L) x 3 1/2" (D). Net weight: 9 lbs. per pair.



#EN-300-036 $249.95 (SUG. LIST) $119.50 (1-3 PRS) $109.90 (4 PRS-UP)

12" Heavy Duty Poly Woofer

Special clear ribbed polypropylene cone with poly foam surround.

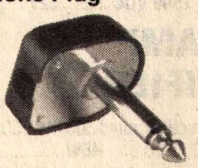


- Power handling: 100 watts RMS/200 watts max.
- Voice coil diameter: 2 inches
- Impedance: 6 ohms
- Frequency response: 23-1500 Hz
- Magnet weight: 40 ozs.
- SPL: 96 dB 1W/1m
- Vas: 12.68
- Qts: .16
- Xmax: .098
- Qes: .18
- Qms: 1.86
- Fs: 23 Hz
- Net Weight: 9 lbs.
- Manufacturer model number: A30GU40-51D
- Dimensions: A: 12-1/8", B: 10-7/8", C: 5-1/2", D: 5-1/2", E: 1-3/4".

#EN-290-125 $41.80 (1-3) $39.90 (4-UP)

Right Angle 1/4" Phone Plug

(Mono)



#EN-099-020 65¢ (1-49) 40¢ (50-up)

The Loudspeaker Design Cookbook IV

This book describes the "science" of loudspeaker design, however applying it is an "art". Using the information in this book will yield hundreds of possible variations in speaker design, with some subtle and not-so-subtle differences. 1991 copyright, fourth edition. Author: Vance Dickason. 154 pages paperback.

#EN-500-035 $29.95 EACH

Cabinet Carpet

This high quality carpet is the covering of choice for car, stage, and amplifier cabinets. Adhere with spray adhesive or latex contact cements. Sold by the linear yard. 54" wide.

#EN-260-765 Dark Charcoal
#EN-260-767 Medium Grey
#EN-260-768 Jet Black

Per Linear Yard, 36" x 54" $4.50

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Dayton, Ohio 45402
Local: 513-222-0173
"FAX: 513-222-4644

- 30 day money back guarantee
- $20.00 minimum order
- We accept Mastercard, Visa, Discover, and company C.O.D. orders
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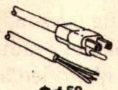
- Shipping charge = UPS chart rate + $1.50 ($4.00 minimum charge
- Hours 8:30 am - 7:00 pm ET, Monday - Friday w9:00 am - 5:00 pm Saturday. Mail order customers, please call for shipping estimate on orders exceeding 5 lbs.
- Foreign destination customers please send $6.00 U.S. funds for catalog postage.

CIRCLE 262 ON FREE INFORMATION CARD

Parts Express
International Inc.

14-3 Heavy Duty Cord



Super duty power cord. 14 ga., 3 conductor. 4 ft. length. Limited availability.

#EN-119-010 $2.50 (1-9) **$1.50** (10-UP)

12 VAC CT, 300 mA Transformer

12VAC (6-0-6) secondary. 300 mA current capability. 2-1/2 ft. primary wires. Dimensions: 2-1/2"(W) X 1-3/8"(H) X 1-1/2" (D).

#EN-129-340 $1.95 (1-9) **$1.70** (10-UP)

VCR Hardware Assortment

Convenient assortment of clips, washers, springs, and screws. 10 pieces each of 4 sizes of "E" clips, 10 pieces of 2 sizes of retaining rings, 10 pieces of 14 sizes of washers, 2 each of 8 sizes of tension and compression springs and 24 assorted screws. Total of 246 pieces.

#EN-430-315 $6.50 (1-3) **$5.95** (4-UP)

Speaker Sealing Caulk

Special rubber compound quickly and easily seals speakers into cabinets. Eliminates vibration and air leaks. Sold in 1/4" x 36" strips.

#EN-269-300 75¢ (1-9) **60¢** (10-UP)

Klein Unibit (reg) Step-Drill Bit

For drilling multiple size holes in metal, plastic and wood up to 1/8" thick. Thirteen steps in 1/32" increments ranging from 1/8" to 1/2" holes. Diameter markings are laser etched on the flute. 1/4" shaft.

#EN-362-100 **$18.95**

Quality 30 Watt Iron

Economical 30 watt iron with replaceable tip. Blue plastic handle.

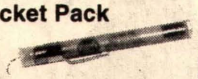
#EN-370-010 **$4.90**

Soldering Stand

Convenient soldering iron stand with cleaning sponge. Display boxed.

#EN-370-020 $4.95 (1-9) **$4.50** (10-UP)

Kester Pocket Pack



Perfect tool box solder supply. The wire feeds conveniently from the handy dispenser tube. Pocket clip attached. .031" diameter solder. .5 ounce (approximately 15 feet).

#EN-370-050 $1.00 (1-9) **90¢** (10-UP)

Parts Express
340 East First St.
Dayton, Ohio 45402
Local: 513-222-0173
FAX: 513-222-4644

Isotip Butane Soldering Iron

The ideal soldering iron for field repairs where no AC power is present. Uses standard butane (not included) available at most stores. Iron also comes with a torch attachment which easily screws on in place of the soldering tip. Limited one year warranty.

#EN-370-235 **$24.95** EACH

Center Off Toggle

DPDT center off toggle switch. 6A, 125VAC. (1/2" mount.)

#EN-060-087 $1.75 (1-9) **$1.50** (10-UP)

Monitor Power Jack

Standard computer type monitor jack. Limited quantity.

#EN-090-446 75¢ (1-49) **65¢** (50-UP)

Screw Type Holder

Standard AGC type fuseholder. Fits 5/8" mounting hole. Black color.

#EN-070-610 65¢ (1-9) **55¢** (10-UP)

Pull-Out Radio Carry Case

Super qua nylon bag storing pul out radios. Front access sory storage pocket which will hold up to 5 CD cases. Velcro closure. Inside dimensions: 7-1/2" x 2-1/2" x 8".

#EN-265-950 $10.80 (1-3) **$9.95** (4-UP)

Matching Transformer

Adapts 75 ohm coax to 300 ohm twin lead (or vice-versa) at antenna or television. 5-90 MHz UHF/VHF. 3 capacitor PC board type.

#EN-180-010 49¢ (1-49) **35¢** (50-UP)

Deluxe F-59 Connector

(Full attached ferrule)

#EN-090-355 22¢ (1-49) **17¢** (50-UP)

Deluxe "F" Male For RG-6

(Full attached ferrule)

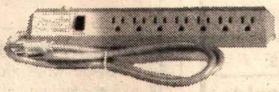
#EN-090-358 29¢ (1-49) **24¢** (50-UP)

Technician's Turntable

Turntable to speed repair of VCRs, TVs and more. Allows technician to easily turn unit for convenient repair. Dimensions: 20"W x 15"D x 1-1/8"H. Black pebbled surface. Includes 4 anti-skid adhesive feet. Net weight: 9 lbs.

#EN-360-427 **$26.80** (EACH)

Surge Protected Power Center



7 outlet power center with noise and surge protection. Surge protection on all three lines (hot, neutral, ground). response time: less than 8 nano seconds. Noise protection on hot to neutral. 15 amp circuit breaker. Lighted power switch. UL listed.

#EN-130-212 $12.50 (1-9) **$10.95** (10-UP)

Universal Video Cable

6 ft. RG-59 cable with a push-on "F" connector to a combination 75 and 300 ohm balun that is switchable between 75 and 300 ohm.

#EN-180-126 $2.95 (1-9) **$2.60** (10-UP)

3.5mm Mini Headphone Extension

Add 6 feet to your mini headphones. Gives the user added mobility when listening to personal cassette players. Limited availability.

#EN-240-090 $1.65 (1-9) **$1.30** (10-UP)

In-Line Coax Splice

Quickly splice coaxial cables with this unique and easy to use splice connector. Accepts up to RG6/U cable.

#EN-090-545 49¢ (1-49) **55¢** (50-UP)

12V, 2.3Ah Camcorder Battery

Popular battery for use with Canon, Chinon, Curtis Mathes, G.E., Magnavox, Minolta, Olympus, Panasonic, J.C. Penny, Pentax, Philco, Quasar, Sears, Sylvania, Teknika and other miscellaneous manufacturers. Dimensions: 7.17" (L) x .94" (W) x 2.42" (H).

#EN-140-541 **$39.95** EACH

Parabond Spray Adhesive

Unique lace spray pattern offers low "soak in" for a better, soft, pliable bond. 20 oz. can comes with an adjustable horizontal or vertical spray fan and adjustable output.

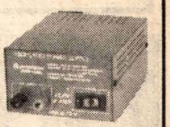
#EN-340-098 $7.95 (1-11) **$6.95** (12-UP)

Pressfit Speaker Terminal

Spring loaded, pushbutton speaker terminal simply drill a hole, apply glue, and press into place.

#EN-260-295 95¢ (1-9) **78¢** (10-UP)

3 Amp Power Supply



This is a fully regulated power supply perfect for testing car radios, CBs, radar detectors and other standard 12VDC items. Heavy duty steel housing with indicator lamp and binding posts. Short circuit protection. Input 120 VAC, 60 Hz. 2 year warranty. Net weight: 4 lbs. Specifications: output voltage 13.8 VDC, output current (cont) 3 amps, output current (surge) 4 amps, dimensions 4-1/2"x3"x7", net weight 4 lbs.

#EN-120-495 $24.80 (1-3) **$23.50** (4-UP)

Unfinished 6" x 9" Cabinets

You can paint or finish to your liking. Flush mount design for rear deck baffle applications. Dimensions: 11-5/8" x 8-3/8" x 6-3/4" x 5" (tapered back). Sold in pairs. Approximate cubic volume: .2 cu. ft. Net weight: 9 lbs. per pair.

#EN-260-450 $12.50 (1-3 PRS) **$9.95** (4 PRS-UP)

Triple Shielded Audio Cables

These high grade oxygen free copper cables utilize triple shielding to ensure excellent noise rejection and are terminated with high conductivity gold plated RCAs for maximum signal transfer. Flexible jacket is sapphire blue and includes a remote turn on wire.

#EN-263-650 (3.3 ft.)	$15.50 (1-3)	**$13.90** (4-UP)
#EN-263-655 (6.8 ft.)	$17.50 (1-3)	**$15.90** (4-UP)
#EN-263-670 (19.8 ft.)	$29.90 (1-3)	**$25.50** (4-UP)

CALL TOLL FREE
1-800-338-0531

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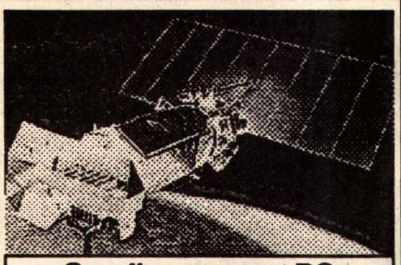

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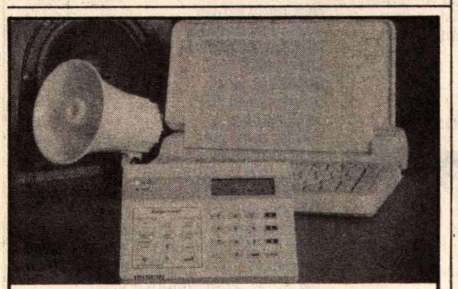

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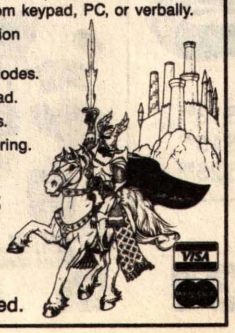

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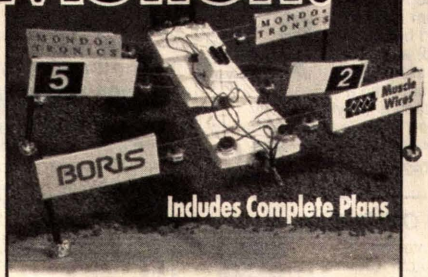

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Resistance (Ω/m)	510	150	50	20
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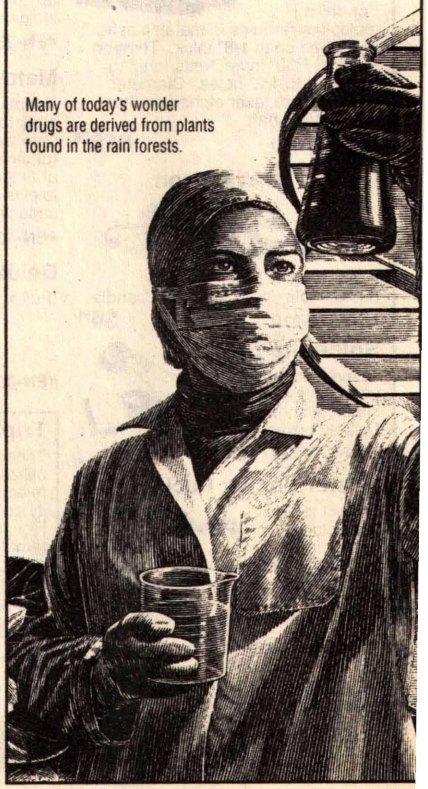
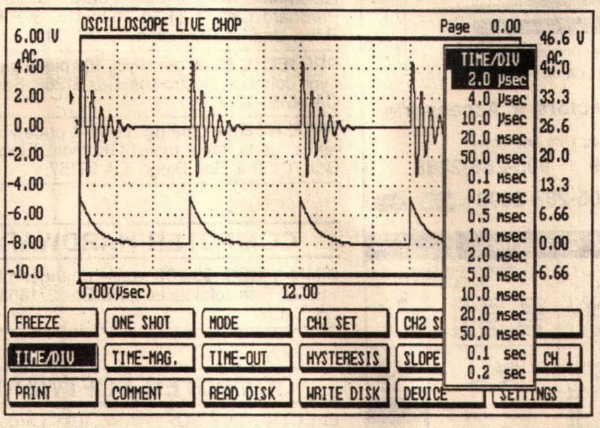
The National Arbor Day Foundation

Many of today's wonder drugs are derived from plants found in the rain forests.



DATA ACQUISITION WITH THE PC



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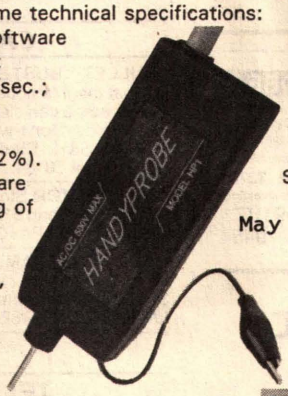

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BEST PERFORMANCE: HANDYSCOPE

The HANDYSCOPE is connected to the parallel printer port. This makes it possible to carry out measurements with a laptop or notebook PC. Due to its high resolution (12 bits), the HANDYSCOPE is a very accurate unit. The measuring time is 100,000 samples/sec. Either of the two channels can be set independently over a range of 0.5 ... 20 volt (with a 1:10 probe up to 200 volt). The advanced software enables many measurements to be carried out. Two probes (switchable 1:1-1:10) are provided. The HANDYSCOPE is constructed as a small table model with two BNC connectors.
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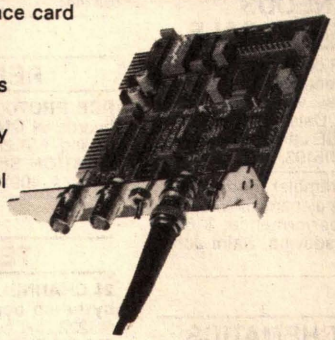
Separately available are 1:1-1:10 probes and 1:100 oscilloscope probes.



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VERY HIGH SPEED: TP208

The TP208 is an interface card with a measuring time of 2x20 Megasamples/sec (8 bits). Phenomena shorter than 1 millionth of a second can still be measured well.
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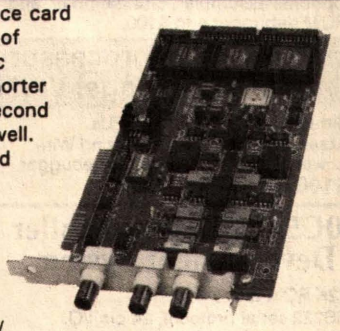

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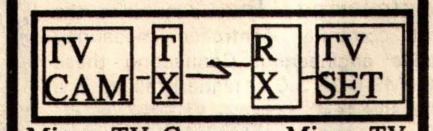

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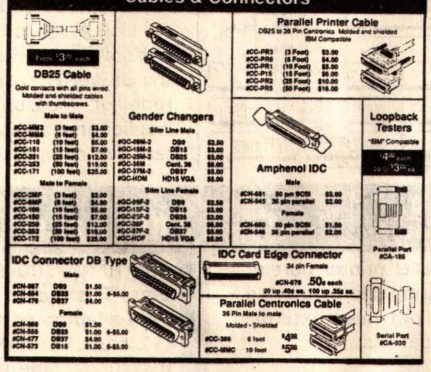

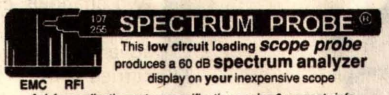

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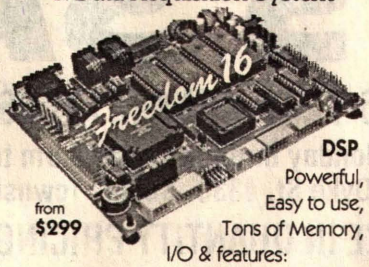

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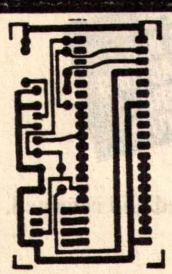

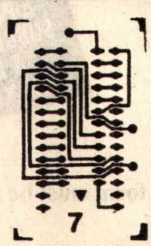

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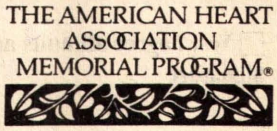

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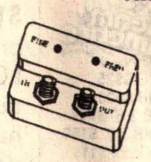

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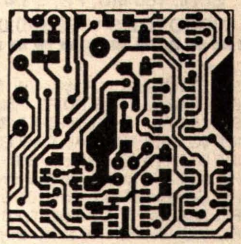

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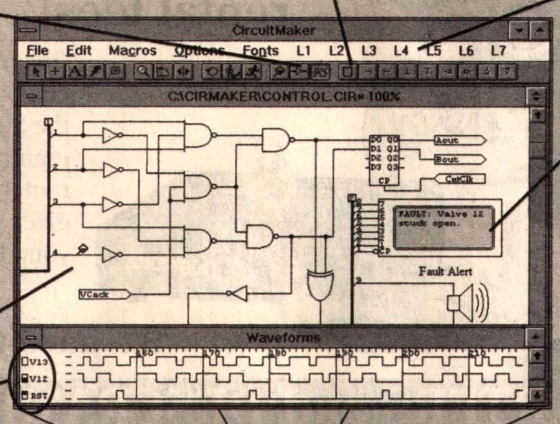

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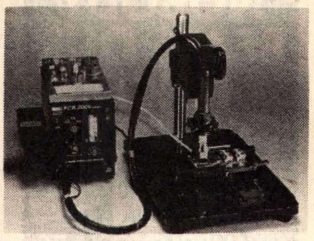

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stand for fixturing the handpiece, and a movable PC-board holder. The system provides a heat timer to control the cycle time and provide repeatability. A vacuum pickup, for removal and/or placement of the component, is built into the handpiece. "Auto" modes will sequence heater and vacuum activation, essentially eliminating the chance for operator error. Handpiece and board fixture make it easy to place and remove components.

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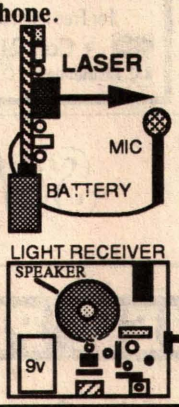

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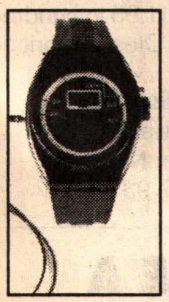

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MODEL TD-RFW
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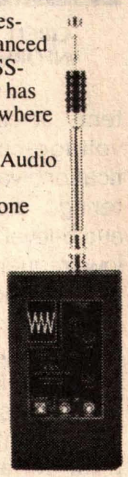

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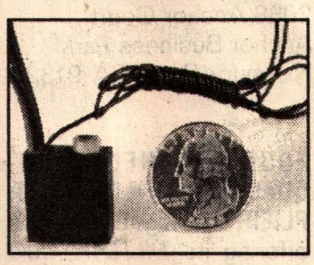

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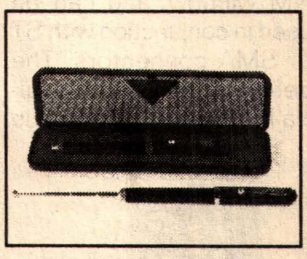

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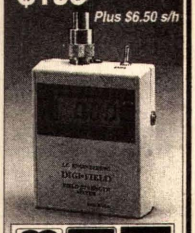
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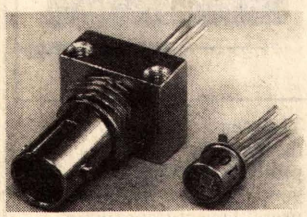

CIRCLE 338 ON FREE INFORMATION CARD

and a high-frequency op-amp in a 6-pin TO-18 package, allowing fiberoptic coupling to be easily achieved without resorting to extremely accurate, more expensive, connectors. According to Centronic, for short-run cables such as LAN's, using the *BPX65-100* at 850 NM can save up to 85% on detector costs.

The *BPX65-100* fiberoptic detector costs $20 in single units; quantity discounts are available.

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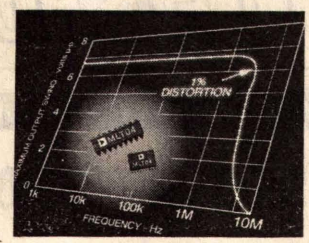

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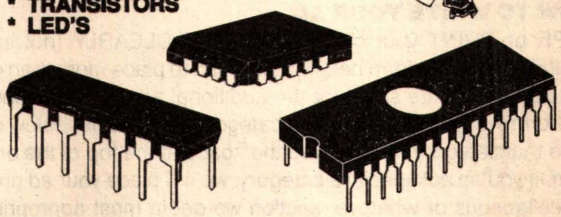

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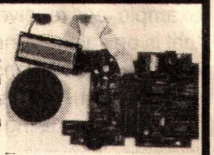
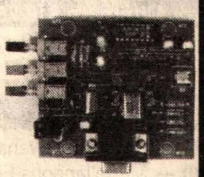

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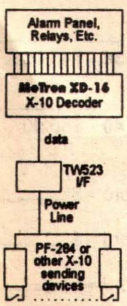

A Typical XD-16 Configuration

The XD-16, when connected to a TW523 Power line data interface module, decodes all 256 X-10 codes sent by PF284, or similar, X-10 senders. The house code is DIP switch selectable. The 16 open- collector outputs are turned on or off as unit and command codes are decoded. Use the XD-16 as an Alarm Panel Interface and save hundreds of dollars in cable installation costs! Or drive relays, LEDs, etc. in custom alarm or house control applications. Requires TW523 data interface. The XD-16 is a 3X3 inch circuit board. Requires 9 to 18 VDC @ 25ma.

MoTron XD-16 X-10 Decoder	$59.00
PS-12 AC Adaptor, 12VDC @ 200ma	$10.00
Powerhouse TW523 X-10 Power Line I/F	$29.00
Powerhouse PF284 X-10 Sender	$29.00

Shipping/Handling $5 USA/Canada, $15 Foreign
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MVDISK2 360k....$150
MVDISK3 1.44m..$195

$75

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THREE EASY STEPS: **$27** 1K QTY
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2. Download to SBC **$95** SGL QTY
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-3 SERIAL -KEYBOARD INPUT
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INSTRUCTION FOR PLACING YOUR AD!

HOW TO WRITE YOUR AD

TYPE or PRINT your classified ad copy CLEARLY (not in all capitals) using the form below. If you wish to place more than one ad, use a separate sheet for the additional ads (a photocopy of this form works well). Choose a category from the list below and write that category number into the space at the top of the order form. If you do not specify a category, we will place your ad under Miscellaneous or whatever section we deem most appropriate.

We cannot bill for classified ads. Payment in full must accompany your order. We do permit repeat ad or multiple ads in the same issue, but in all cases, full payment must accompany your order.

WHAT WE DO

The first two words of each ad are set in bold caps at no extra charge. No special positioning, centering, dots, extra space, etc. can be accommodated.

RATES

Our classified ad rate is $1.25 per word. Minimum charge is $18.75 per ad per insertion (15 words). Any words that you want set in bold or caps are 20¢ each extra. Bold caps are 40¢ each extra. Indicate bold words by underlining. Words normally written in all caps and accepted abbreviations are not charged as all-caps words. State abbreviations must be Post Office 2-letter abbreviations. A phone number is one word.

CONTENT

All classified advertising in the **Electronic Shopper** is limited to electronics items only. All ads are subject to the publisher's approval. We reserve the right to reject or edit all ads.

DEADLINES

Ads received by our closing date will run in the next issue. For example, ads received by April 1 will appear in the July, 1993 issue that is on sale in June 3. Shopper ads will appear Jan., Mar., May etc. No cancellations permitted after the closing date. No copy changes can be made after we have typeset your ad. NO REFUNDS, advertising credit only. No phone orders.

AD RATES: $1.25 per word, Minimum $18.75.

Send your ads with payment to:
Electronic SHOPPER, 500-B Bi-County Blvd. Farmingdale, NY 11735

CATEGORIES

100 — Antique Electronics
130 — Audio-Video-Lasers
160 — Business Opportunities
190 — Cable TV
210 — CB-Scanners
240 — Components
270 — Computer Equipment Wanted
300 — Computer Hardware
330 — Computer Software
360 — Education
390 — FAX
420 — Ham Gear For Sale
450 — Ham Gear Wanted
480 — Miscellaneous Electronics For Sale
510 — Miscellaneous Electronics Wanted
540 — Music & Accessories
570 — Plans-Kits-Schematics
600 — Publications
630 — Repairs-Services
660 — Satellite Equipment
690 — Security
710 — Telephone
720 — Test Equipment

CLASSIFIED AD COPY ORDER FORM

Ad No. 1—Place this ad in Category # _____

1 - $18.75	**2** - $18.75	**3** - $18.75	**4** - $18.75
5 - $18.75	**6** - $18.75	**7** - $18.75	**8** - $18.75
9 - $18.75	**10** - $18.75	**11** - $18.75	**12** - $18.75
13 - $18.75	**14** - $18.75	**15** - $18.75	**16** - $20.00
17 - $21.25	**18** - $22.50	**19** - $23.75	**20** - $25.00
21 - $26.25	**22** - $27.50	**23** - $28.75	**24** - $30.00
25 - $31.25	**26** - $32.50	**27** - $33.75	**28** - $35.00

29 - $36.25	**30** - $37.50	**31** - $38.75	**32** - $40.00
33 - $41.25	**34** - $42.50	**35** - $43.75	**36** - $45.00
37 - $46.25	**38** - $47.50	**39** - $48.75	**40** - $50.00

Ad No 1—Total words _____ × $1.25 per word = $ _____

All Caps words _____ × .20 per word = $ _____

Bold words _____ × .20 per word = $ _____

Bold Cap words _____ × .40 per word = $ _____

TOTAL COST OF AD No. 1 $ _____

Total classified ad Payment $ _____ enclosed.

[ ] Check [ ] MasterCharge [ ] Visa ($18.75 minimum credit card order)

Card # _____

Expiration Date __ __ / __ __

Signature _____

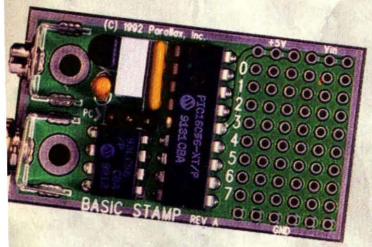
Name _____ Phone _____

Address _____ City State Zip _____

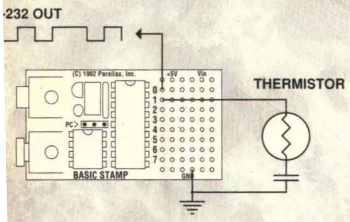
THE BASIC STAMP™

$39 Stamp-Sized Computer Runs BASIC

EDN INNOVATION '93 — DRIVING ELECTRONIC TECHNOLOGY INTO THE NEXT CENTURY



The BASIC Stamp is a 1x2-inch computer that runs BASIC programs written on your PC. It has 8 I/O lines, which can easily be programmed for serial communications, potentiometer input, pulse measurement, button debounce, tone generation, PWM, etc. And all by just adding a resistor and/or capacitor, if anything. Single Stamps sell for $39, and quantity prices start at just four units.

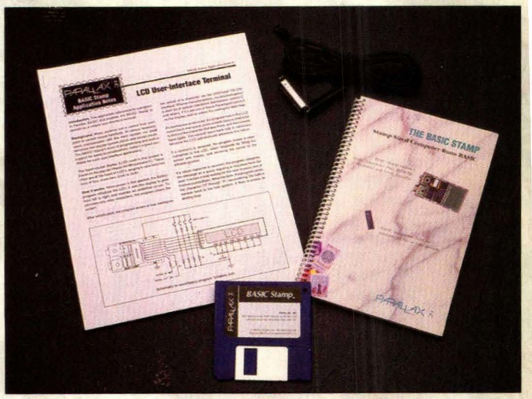


emperature Sensor

this application, the Stamp es a capacitor and Radio Shack ermistor to take temperature adings. 13 BASIC instructions e used to read and linearize the put. The result is then sent out rially.

Writing programs for the Stamp is easy. A 3-pin cable connects the Stamp to your PC's parallel port. And one piece of software is used to enter, debug, and download your programs. It's as simple as possible.

All that you need to program Stamps is included in the Stamp Programming Package. The package contains the cable and software mentioned above, as well as a manual, application notes, and access to free technical support.



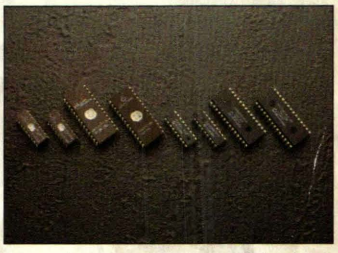
Stamp Programming Package **$99**

PIC®16Cxx MICROCONTROLLERS and TOOLS

nexpensive and available, PICs are building a following

ou may already know about the PIC16Cxx series of 8-bit microcontrollers from icrochip Technology. They're the answer to many small controller needs, pecially if price if an issue. A typical PIC is the PIC16C54-RC/P; it's an 18-pin DIP ckage with 12 I/O lines, 512 words of PROM, and 32 bytes of RAM, all for ound $4.00 in small quantities. And the series continues to grow: new PICs have terrupts, A/D, and up to 33 I/O lines.

r the past three years, we've been helping people get started with PICs. We offer w-cost development tools, documentation, application notes, and technical help, well as the PICs themselves.

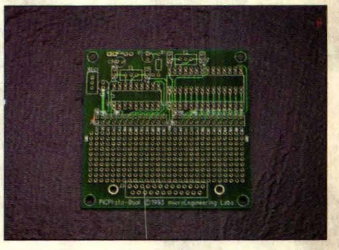


PIC Chips **$4 - $27**
We offer PICs in the "RC" and EPROM versions.

16Cxx Programmer $199
ports PIC16C5x, '71, & '84.
PIC16C64 with 40-pin adapter.

PIC16C5x Downloader $299
Plugs in place of '5x PIC in-circuit. Runs code at 8 MHz.

TrueFlight™ for '71/'84 $299
Programmer & flash UV eraser form development system for '71 & '84.



PIC Prototype Board **$15**
Provides an easy way to develop circuits with 18- and 28-pin PICs.

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DC-2000 MHz

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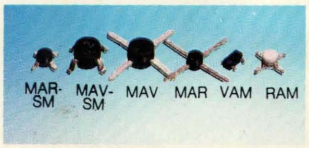
In plastic and ceramic packages, for low-cost solutions to dozens of application requirements, select Mini-Circuits' flatpack or surface-mount wideband monolithic amplifiers. For example, cascade three MAR-2 monolithic amplifiers and end up with a 25dB gain, 0.3 to 2000MHz amplifier for less than $4.50. Design values and circuit board layout available on request.

It's just as easy to create an amplifier that meets other specific needs, whether it be low noise, high gain, or medium power. Select from Mini-Circuits' wide assortment of models (see Chart), sketch a simple interconnect layout, and the design is done. Each model is characterized with S parameter data included in our 740-page RF/IF Designers' Handbook.

All Mini-Circuits' amplifiers feature tight unit-to-unit repeatability, high reliability, a one-year guarantee, tape and reel packaging, off-the-shelf availability, with prices starting at 99 cents.

Mini-Circuits' monolithic amplifiers...for innovative do-it-yourself problem solvers.



Models above shown actual size

from **99¢** Unit price $ (25 qty)

PLASTIC SURFACE-MOUNT			++VAM-3 1.45		+VAM-6 1.29	++VAM-7 1.75		
add suffix SM to model no. (ex. MAR-ISM)	MAR-1 1.04	MAR-2 1.40	MAR-3 1.50	MAR-4 1.60	MAR-6 1.34	MAR-7 1.80	MAR-8 1.75	
	MAV-1 1.15	+MAV-2 1.45	+MAV-3 1.55	MAV-4 1.65				MAV 2.15
CERAMIC SURFACE-MOUNT	RAM-1 4.95	RAM-2 4.95	RAM-3 4.95	RAM-4 4.95	RAM-6 4.95	RAM-7 4.95	RAM-8 4.95	
PLASTIC FLAT-PACK	MAV-1 1.10	+MAV-2 1.40	+MAV-3 1.50	+MAV-4 1.60				MAV 2.10
	MAR-1 0.99	MAR-2 1.35	MAR-3 1.45	MAR-4 1.55	MAR-6 1.29	MAR-7 1.75	MAR-8 1.70	
Freq.MHz,DC to	1000	2000	2000	1000	2000	2000	1000	1000
Gain, dB at 100MHz	18.5	12.5	12.5	8.3	20	13.5	32.5	12.7
Output Pwr. +dBm	1.5	4.5	10.0	12.5	2.0	5.5	12.5	17.5
NF, dB	5.5	6.5	6.0	6.5	3.0	5.0	3.3	3.6

Notes: + Frequency range DC-1500MHz ++ Gain 1/2 dB less than shown

designer's kit, KH-1 available only $59.95 includes:
40 AMPLIFIERS* 10 MAR-1, 10 MAR-3, 10 MAR-4, 10 MAR-8
150 CAPACITORS* 50 100 pf, 50 1,000 pf, 50 10,000 pf
740 page RF/IF DESIGNER'S HANDBOOK
• MIXERS • POWER SPLITTER/COMBINERS • AMPLIFIERS • ELECTRONIC ATTENUA
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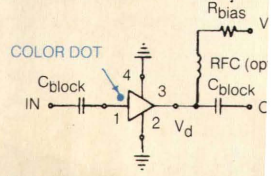
• FILTERS • LIMITERS • FREQUENCY DOUBLERS
*values or models may be substituted without notice, depending on supplies.

Typical Circuit Arrangeme



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